AgResults Baseline Report: Kenya On-Farm Storage Pilot

FINAL

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20 April 2015

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Preface

AgResults is a $110 million multilateral initiative incentivizing and rewarding high-impact agricultural innovations that promote global food security, health, and nutrition through the design and implementation of pull mechanism pilots. It is funded by the governments of Australia, Canada, the United Kingdom, the United States, and the Bill & Melinda Gates Foundation, and managed through a Financial Intermediary Fund operated by the World Bank. By using pull mechanisms, AgResults extends beyond traditional aid measures to promote the adoption of innovative technologies with high-yield development impact. AgResults will provide economic incentives to private sector actors in smallholder agriculture to develop and ensure the uptake of innovative technologies with the potential to yield high development impacts. It will help overcome market failures impeding the establishment of sustainable commercial markets for such technologies, or goods produced by means of them, and thereby achieve substantial and sustained development impacts, manifested in improved food security and food safety, increased smallholder incomes, and better health and nutrition. It will call upon the ingenuity and drive of the private sector to identify and execute the most effective and efficient strategies to achieve development outcomes.

The AgResults program team comprises a Steering Committee, a Secretariat, a Trustee, country-specific pilot implementers, and an external evaluator. The Steering Committee oversees the implementation of AgResults and is comprised of the five donor agencies and the Trustee. The Steering Committee is responsible for strategic oversight of the initiative, including endorsement of key management decisions, approval of concepts and business plans for proposed pilots, and the monitoring of pilots and the initiative as a whole. The Secretariat is responsible for implementation of the AgResults Initiative and reports to the Steering Committee. In order to fulfil its role effectively, the Secretariat develops a close working relationship with the Trustee and ongoing external evaluator. Core functions include appointing and managing pilot implementation and verification agents, sourcing new pilots, and communicating results. As Trustee for AgResults, the World Bank provides an agreed set of financial intermediary services that include receiving funds, holding funds, investing funds, and transferring them to recipients or other agencies for implementation as directed by the Secretariat on behalf of the Steering Committee.

In Kenya, AgResults is funding an on-farm storage pilot that stimulates improved food security through the widespread adoption of improved on-farm grain storage solutions for smallholder farmers in the Rift Valley and Eastern regions of Kenya. The pilot is designed to demonstrate a successful model for developing and marketing low-cost storage solutions for smallholder farmers by offering cash prize payments to private sector companies based on the volume of low-cost storage capacity sold within a given timeframe. The Kenya pilot is scheduled to run through May 2018 (assuming the pilot starts in May 2015 as planned).

Agribusiness Systems International (ASI), a wholly controlled affiliate of ACDI/VOCA, serves as Pilot Manager for the Kenya pilot. As Pilot Manager, ASI is managing overall implementation of the pilot. This includes marketing, promoting, and overseeing the selection process of potential implementers; liaising with international organizations and relevant government ministries; reporting on the progress of the pilot and the approved indicators; overseeing verification and managing the final data analysis to calculate funds disbursements; and

documenting and reporting lessons learnt to the Secretariat in a Quarterly Report and in a report following an annual lessons learned event with implementers, once the sales period begins. The Secretariat will share lessons learnt with the broader stakeholder community via the AgResults website, blog and social media.

The Steering Committee appointed Abt Associates Inc. to serve as the External Impact Evaluator for the AgResults pilots, including the Kenya on-farm storage pilot. Abt's role is to determine on a rigorous scientific basis if the pull mechanisms achieve their objectives of catalysing private sector investments that address underlying market failures, resulting in social outcomes that are different from, and better than, what would have happened in the absence of the mechanism introduced by the pilot initiatives. We will also address the sustainability of the results produced in the private market once the pilot incentives are removed. In our role as the External Impact Evaluator, Abt defines an overall evaluation framework for the AgResults Initiative and an impact analysis strategy for each pilot. We implement and analyse field surveys based on established best practices, conduct qualitative market analyses, and communicate evaluation findings to the Steering Committee and wider audiences as needed. Our role is vital to the AgResults learning agenda of understanding the potential of private sector involvement in the development and spread of agricultural innovation. The evaluation timeframe is 2013 to 2019 (assuming extension of the contract following delays in the start of the Kenya pilot).

This report presents Abt's baseline findings for the Kenya pilot based on qualitative and quantitative data collected during mid- to late-2014 following the protocol set out in the June 2014 evaluation design report we refer to throughout this document (Abt Associates, 2014). The reference period for this data collection was the 2013 harvest seasons (February-March and July-August in Eastern, where there are two seasons, and October-January in Rift Valley, where there is only one season; see Appendix A for further information on maize-growing seasons in both regions). Since the pilot launch has been delayed to 2015, Abt will field another round of baseline smallholder household-level data collection in mid-2015 to capture information on key outcomes for 2014's harvest seasons. After that survey, we will submit an updated baseline report that incorporates the new data and extends our analysis of pre-program trends through 2014.

The Kenya evaluation team is led by Tulika Narayan, with the core quantitative team comprising Betsy Ness-Edelstein (also the country coordinator), Sung-Woo Cho, and Fatih Unlu. Denise Mainville from Denise Mainville Consulting leads the qualitative analysis working with Tabitha Nduku, in-country agricultural economist, and the quantitative team, who also contributed to qualitative investigation. Stephen Bell, the AgResults Team Leader, provides technical advice and quality control of research reports. To date, the Kenya pilot's evaluation design has benefited from comments and inputs from the external peer reviewers Kelsey Jack, Mushfiq Mobarak, and Ephraim Nkonya. The evaluation design report also benefited from comments from the AgResults Steering Committee and members of the Kenya pilot implementation team in Deloitte and ASI.

Executive summary

AgResults is a $110 million multilateral initiative incentivizing and rewarding high-impact agricultural innovations that promote global food security, health, and nutrition through the design and implementation of "pull mechanism" pilots. Pull mechanisms incentivize the private sector to overcome market imperfections using prizes for achieving pre-defined results without preference to strategies and technologies involved in achieving these results. In Kenya, AgResults is funding an on-farm storage pilot aiming to improve food security by stimulating the market for improved on-farm grain storage (OFS) solutions for smallholder farmers in the Rift Valley and Eastern regions of the country. The pilot aims to combat the many post-harvest loss challenges farmers face with stored cereal and pulse crops, such as insect and rodent damage, aflatoxins and other mould, theft, and various pressures to sell harvests quickly when market prices are depressed rather than storing crops longer to take advantage of better prices. The pilot offers cash payments to private sector companies based on the volume of low-cost storage capacity sold during the pilot's three-year timeframe. The goal is to incentivise these "implementers" to increase sales of OFS to smallholders and make the results sustainable after the incentive payments are discontinued.

Abt Associates Inc. is the External Impact Evaluator for the AgResults pilots, including the Kenya on-farm storage pilot. As evaluator, Abt's role is to determine on a rigorous scientific basis if the pull mechanisms achieve their objectives of catalysing private sector investments that address underlying market failures, resulting in social outcomes that are different from, and better than, what would have happened in the absence of the mechanism introduced by the pilots. The evaluation will also examine the sustainability of the results produced in the private market once the pilot incentives are removed. The evaluation timeframe is 2013 to 2019 (assuming extension of the contract following delays in the start of the Kenya pilot).

Abt Associates conducted qualitative and quantitative research in Kenya during mid- to late 2014 to understand baseline conditions of both the OFS market and the smallholder farmer population being targeted by the pilot. This information will form a basis for answering AgResults' key research questions, initially based on starting conditions and over time as pilot results are observed in coming years:

1. What is the impact of the AgResults pilot on private sector engagement in the development and uptake of on-farm storage?
2. What is the impact of the AgResults pilot on smallholders' uptake of on-farm storage?
3. What is the impact of the AgResults pilot on smallholder income?
4. What is the impact of the AgResults pilot on consumers' demand for derivative products? *[not relevant for Kenya pilot]*
5. What evidence exists that the effects of the AgResults pilot will be sustainable in the medium to long term?
6. What is the evidence on the scale of any effect on private sector investment and uptake and on the cost-effectiveness of AgResults as an approach? *[not addressable at baseline]*
7. What lessons can be learnt about best practices in the design and implementation of agricultural pull mechanisms?

Baseline methods and data

To understand basic conditions of the OFS market at baseline as they relate to Research Question 1 on private sector engagement, the evaluation relies on a Structure, Conduct, Performance (SCP) framework, which examines the interplay between product supply and demand conditions and the institutional environment, individual firms' strategies, and the structure and performance of the market. As such, data collection involved semi-structured interviews focused on eliciting information on firms' and farmers' perceptions of the conditions underlying the market for improved OFS and their strategies for engaging (or not) in the OFS market. (Information on farmer perspectives also came from the large sample smallholder survey described below.) Data collection also focused on understanding the factors that are likely to influence the participation of specific groups in the OFS market, such as women and the poorest farmers, and the benefits they may obtain from participation.

To answer Research Questions 2 and 3, the evaluation will employ a short interrupted time series (SITS) approach to estimate the impact of the pilot on three key outcome measures—smallholders' uptake of on-farm storage solutions, food security, and smallholder income. The SITS method compares the pre-pilot time trend on key outcomes to post-pilot levels and measures the intervention's impact as the departure of actual outcomes from the expected levels absent the intervention. Because a geographical comparison area was not tenable, the evaluation will attempt to account for other sources of bias by using an unaffected outcome. This procedure will remove any bias that arises from confounders that skew the unaffected outcome in a like manner to the affected outcomes. This approach entails developing a time trend of measure that is not specifically targeted by the program but influenced by the confounders in the same way as the targeted primary outcome measure. We have proposed using *maize yield* as an unaffected outcome because we believe that maize yield per hectare may not be impacted by the pilot, thus serving as an unaffected outcome measure for either of the two primary targeted outcomes (uptake of on-farm storage and maize revenue).

We present disaggregation of results by the gender of the household head and by poverty status of the households measured using the Poverty Assessment Tool (PAT) developed by USAID, which identifies a set of variables that serve as a proxy for poverty.

A baseline survey of 4,765 farmers collected three annual observations of the critical outcome measures prior to implementation of the pilot using retrospective questions regarding the 2011, 2012, and 2013 harvest seasons. We also collected information on additional outcomes for 2013, including awareness of the benefits and correct use of improved OFS, knowledge and attitudes about other storage practices, to be included in a before-versus-after analysis. A second farmer survey in 2015 will obtain information on the 2014 harvest season, which will be the last pre-intervention observation before implementation begins. Later, at the endline, we will gather information on three post-intervention time period (2015, 2016, and 2017) to complete the impact analysis as described in the evaluation design report.

For the SITS analysis, we collected quantitative data from 4,765 randomly selected smallholder households mid- to late 2014 across all counties in both pilot target regions, Rift Valley and Eastern, from a list of areas based on their likelihood of being targeted by OFS suppliers. Households were screened prior to being interviewed to ensure they were cereal- or pulse-producing households and farmed an amount of land which would qualify them as a small- or

medium-holder rather than a large farm. The reference period for this data collection was the 2013 harvest seasons (February-March and July-August in Eastern, where there are two seasons, and October-January in Rift Valley, where there is only one season; see Appendix A for further information on maize-growing seasons in both regions).

The smallholder data show that 23% of respondent households in the Eastern region and 17% in Rift Valley are female-headed, and all grew at least one of the cereal or pulse crops capable of being stored in improved OFS technologies during the reference year (2013). Households in the sample own, on average, 1.2 ha of land in Eastern and 1.7 ha in Rift Valley and tend to cultivate slightly less than that each season (about 1.1 ha in Eastern and 1.2 ha in Rift Valley). Average household income for smallholders during the reference period (the 2013 agricultural cycle plus the most recent 12 months of wage/labour income) was KES 218,994 in the Eastern counties (about US$2433 at the current exchange rate) and KES 197,510 in Rift Valley (about US$2195). The vast majority of this income, on average, comes from household labour (KES 218,952 in Eastern and KES 186,528 in Rift Valley) rather than agricultural revenue (only KES 42 in Eastern and KES10,982 in Rift Valley), indicating that, while these are farming households, the norm is subsistence rather than commercial agriculture. Farmers report cultivating a fairly limited mix of crops in the 2013 long rainy season. Maize was by far the most popular crop, grown by 98% of Eastern households and close to 100% of Rift Valley households, while common beans were second in both regions (grown by 73% of Eastern households and 66% of Rift Valley households). Other crops were far less commonly grown, and all crops grown by more than 5% of farmers can be characterised as staple grains, pulses, and starches. In the Eastern counties, where there is a second cropping season each year, the cropping mix is similar, with maize and beans covering the largest share of respondents' land during the 2013 short season.

Evaluation Question 1: What is the impact of the AgResults pilot on private sector engagement in the development and uptake of on-farm storage?

Baseline findings are generally consistent with the AgResults Kenya business plan (Dalberg, 2012), supporting the hypothesis that, despite severe storage constraints, there is limited awareness, availability, and use of improved OFS solutions with the potential to reduce the storage losses faced by smallholders. OFS suppliers perceive these constraints as particularly relevant to sale of improved OFS for cereals and grains compared to other more profitable, crops such as coffee. Commercial distributors, which act as intermediaries between suppliers and smallholders, considered smallholders to offer a strong potential market for improved OFS products, and a large majority of distributors (80%) said they would consider carrying one or more improved OFS options if they were given the opportunity to do so. Respondents felt that farmer demand would be highest for improved OFS products that were effective in combatting weevils and the larger grain borer (LGB), familiar and easy to use, durable, and affordable.

Despite the presence of some improved OFS options, the current situation for improved OFS can best be characterized as a "missing market" in that a latent demand exists for a product without corresponding commercial availability to meet that demand. This situation exists despite indications that both the size of the potential market base and latent demand for the product are sufficient to sustain commercial activity. However, OFS suppliers indicate that improved OFS products are most likely to reach farmers who are relatively better off, as these are often the farmers who frequent commercial agro-input distributors or participate in farmer organizations.

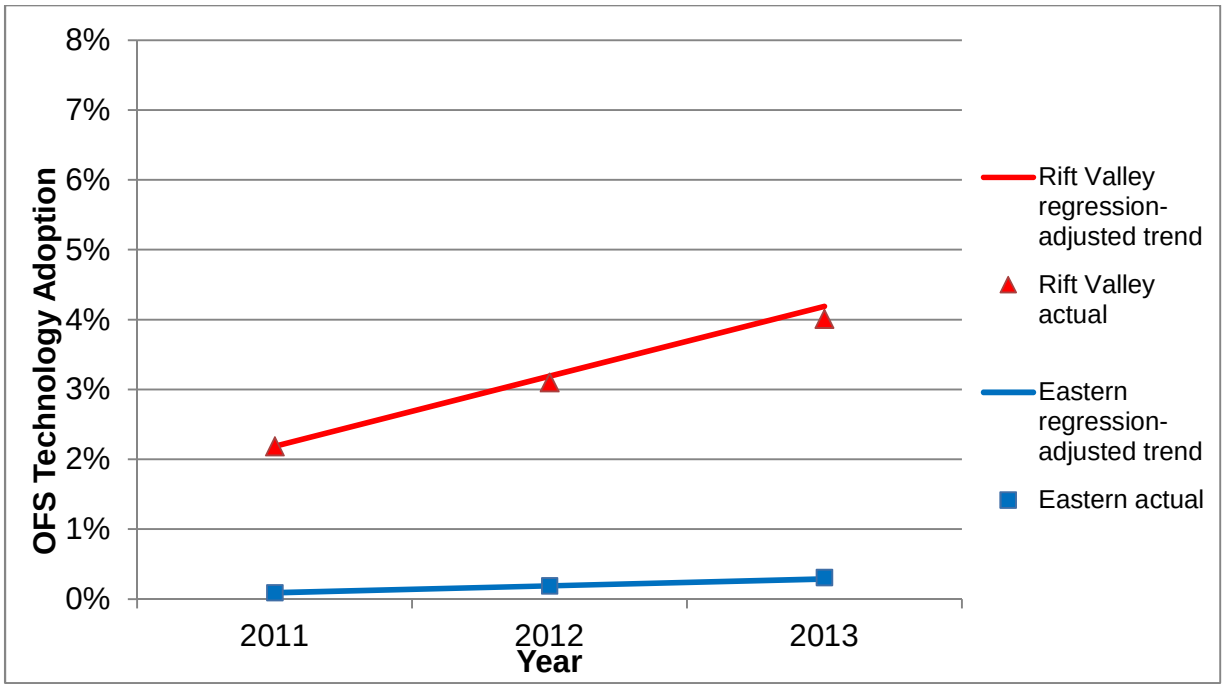
Thus, they are most likely to be exposed to and able to afford improved OFS. Based on firms' and farmers' perceptions of the product and its potential market, AgResults could catalyse investment at a scale and diversity of approaches sufficient to create a dynamic and sustained market.

Evaluation Question 2: What is the impact of the AgResults pilot on smallholders' uptake of on-farm storage?

Prior to the AgResults pilot, smallholder awareness and adoption of improved OFS technologies is low. Survey data suggest that only about 10% of respondents in the Eastern counties and 12% in Rift Valley are aware of at least one improved OFS option, and just 0.3% of the households in the Eastern counties and 4% of the households in Rift Valley report purchasing any of the improved OFS technologies that AgResults may promote (almost all PICS bags). This is expected given that only a few of these technologies are currently available through agro-suppliers in these regions.

Using three data points on uptake of OFS in 2013, 2012, and 2011, the trend was flat in the Eastern region and relatively positive in the Rift Valley region. Uptake of OFS in the Eastern region increased by about 0.1 percentage point, while the maize revenues in the Rift Valley region increased by about 1 percentage point over time (see Figure 1). We conducted analyses separately for vulnerable groups, notably female-headed households and households classified as poor. The disaggregation by region, gender, and poverty status reveals that there is also very little difference across subgroups in the trends in the adoption of improved OFS over time.

Figure 1. OFS adoption trend lines for the Eastern and Rift Valley regions, fitted by regressing yearly figures reported by the baseline survey



Current post-harvest practices before the AgResults pilot are important to assess the extent to which adoption of improved OFS will yield positive results. Grain must be clean, dry, and (in the

case of hermetic bags) stored on a raised platform away from walls for farmers to reap the full benefits of improved OFS technologies. If farmers fail to create these conditions, the pilot may not have its full intended effect. Therefore, for the pilot to have sustainable impact on the adoption of OFS, it will have to generate broader awareness about post-harvest handling practices. The results suggest that there are gaps in the knowledge about what is a good practice. Drying grains is perhaps the most important step in successful adoption of OFS, and the results suggest that farmers are aware of this (almost all farmers report drying their grain and testing for moisture); however, they do not have knowledge about (and potentially access to) improved methods to dry their grain or do not know that they are best practices. For example, most farmers in the Eastern region (more than 80%) say they dry cobs on the ground and believe that to be a best practice; the same is true for just over half of Rift Valley farmers.

For moisture testing, nearly 75% of farmers in the Eastern region prefer using the sound the grain makes to gauge if it is dry enough; just over a third also mention biting kernels to test for dryness. In Rift Valley, the proportions were nearly opposite: about 43% say they listen to the sound the grain makes, while about three-quarters prefer to measure dryness by biting the kernels. Although not as critical as drying, proper shelling is important to ensure the efficacy of improved OFS. Shelling by beating can cause grain damage, leading to greater exposure to insects and fungus. Most farmers (around 70%) in the Eastern region report that shelling by beating is the best shelling practice and the one they use. About 45% prefer shelling by hand in the Eastern region. In Rift Valley, respondents are more split: 54.7% say shelling by beating is the best practice, and 50.4% say that is what they do; 49.9% say machine shelling is the best practice, and 39.5% say that is what they do; and 26.3% say that hand-shelling is the best practice, with 23.4% saying they practice hand shelling.

Once the grain is dried and bagged, access to improved storage facilities is another critical step in ensuring that full benefits of certain OFS solutions (i.e., bags) are realized. The baseline data suggest that storage inside the home is the most common practice for preserving grain: 43% of Eastern farmers and 20% of Rift Valley farmers keep a room in their home specifically for storage, while another 31% in Eastern and 23% in Rift Valley store their crops in the living rooms of the house (i.e., living and sleeping areas). Improved granaries with wooden walls are also fairly popular in Rift Valley, used by 33% of farmers, while only 10% use these in the Eastern counties. Eleven percent of farmers in Eastern use traditional cribs, while 13% use them in Rift Valley. All other types of on-farm storage facilities, including improved granaries with wicker walls, separate storage structures, traditional storage over the kitchen fire, and baskets, are used by 4% or fewer of households.

Key informant interviews with sub-county agricultural officers (SCAOs) offered insight into the interplay between the strategies farmers use to mitigate storage losses and environmental conditions. While many SCAOs report that farmers store grains in their houses to reduce the risk of theft, they also note that this causes its own problems due to inadequate ventilation that increases storage losses from too much moisture. Lack of use of dryers or moisture meters also precludes farmers from drying grain adequately before putting it into storage. Likewise, while farmers are reported to dust with chemicals to mitigate pest problems (such as weevils and LGB), numerous SCAOs observed that these chemicals are often either ineffective or incorrectly applied.

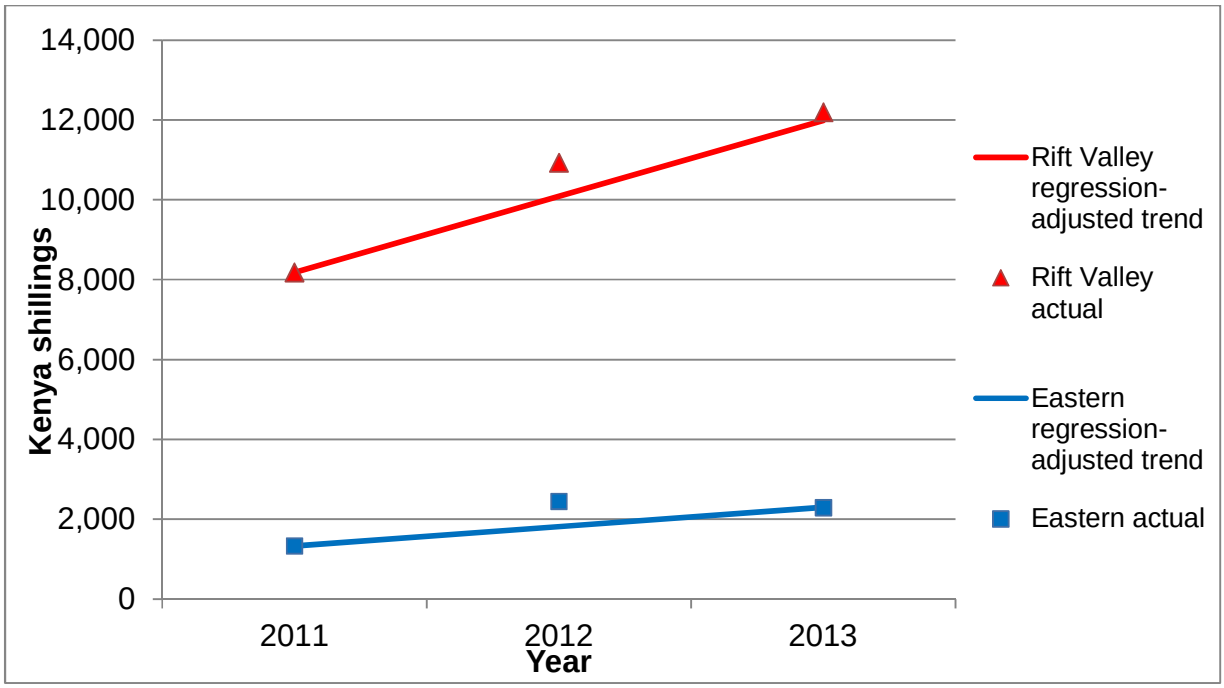
Evaluation Question 3: What is the impact of the AgResults pilot on smallholder income?

To set the stage for later impact analysis, we examined the baseline trend in maize revenue as a proxy for smallholder income, as it is the strongest mechanism through which farm net income is likely to be affected by AgResults. Moreover, as discussed in the evaluation design report, we did not propose assessing the impact on smallholder income or net maize revenue because obtaining recall data on smallholder incomes or maize production costs to develop a time trend for the SITS analysis would not have been feasible without significant recall error.

Overall, farmers report higher maize production and sales in the Rift Valley than in the Eastern counties for the 2013 long rainy season. In Eastern counties, households produced an average of 358.2 kg of dry maize and 48.6 kg of green maize, while in the Rift Valley they averaged 1,184 kg of dry maize and 70 kg of green maize. Less than 17% of farmers in the Eastern region reported selling any maize, while about 41% in the Rift Valley reported selling maize. (Sales of other crops tended to be even less common, as they are generally grown for home consumption rather than sale.)

The trend in inflation-adjusted maize revenue over the 2011 to 2013 period was positive in both regions, with a steeper trend in the Rift Valley region (see Figure 2). Measured revenues in the Eastern region increased by about KES 485 annually (in 2010 prices), while the maize revenues in the Rift Valley region increased KES 1,907 per year.

Figure 2. Maize revenue trend lines for Eastern and Rift Valley regions, from baseline smallholder survey, fitted by regressing yearly figures reported by baseline survey respondents



We find no evidence that trends differed between male-headed and female-headed households in the Eastern region, but a suggestion (at the 10% statistical significance level) appears in the Rift

Valley region, with male-headed households exhibiting a strong upward trend and female-headed households showing little growth. When we disaggregate by poverty levels, the Eastern region's poor households exhibit a trend in maize revenue quite different from the non-poor, with the non-poor households exhibiting a strong positive trend and very poor households showing little trend. However, the Rift Valley does not exhibit a statistically significant difference between its very poor and non-poor households, with both groups showing positive trends.

Perhaps the biggest impact of the pilot may be on the amount of grain available to households for their own consumption if better OFS technologies are used. For the 2013 growing season, 58% of households in both regions report running out of maize between harvests. The survey also elicited households' food security situation more generally by asking them to list the months in which they were food insecure during the past 12 months. Responses to this question suggest that hunger and food insecurity occur for less than 10% of interviewed households. The updated report after the 2015 survey will include the baseline trends in the number of months between finishing the maize harvest and running out of maize stored for household consumption, which we do not report here because of lack of complete data needed to develop the time trend.

Evaluation Question 5: What evidence exists that the effects of the AgResults pilot will be sustainable in the medium to long term?

The SCP analysis also offers insights into the potential sustainability of the pilot's effects on private sector engagement in the market, should such effects occur. The essential issue is whether private sector players still continue to invest and act in the improved OFS market once the pull mechanism incentives are removed. This may depend on realization of suppliers' sales goals during the pilot period, which could in turn depend heavily on effective promotion of OFS solutions to farmers. At the local level, the emergence of sustained markets is more likely in areas where smallholder farmers are more exposed to improved OFS promotions by shopping at participating commercial distributors or participating in farmer organizations that distribute the OFS solutions and have financing available to acquire new products. This implies that sales will be strongest in higher-potential agricultural areas where the crops sales are high.

A related consideration is the extent and depth to which the pilot impacts the awareness and knowledge of the farmers. Farmers need to have a broad understanding of improved post-harvest storage handling practices such as drying and testing of moisture to realize the full benefits of improved OFS. If the OFS suppliers and distributors generate broader awareness about these aspects, the likelihood of market impact over the long run will increase.

Evaluation Question 6: What is the evidence on the scale of any effect on private sector investment and uptake and on the cost-effectiveness of AgResults as an approach?

This question is best answered after endline data are available to assess the impact and cost-effectiveness of the pilot. In answering this question, we will compare the firms' projections about the scale they expect to reach and what they actually did. Since the pilot is not yet launched and the firms are continuing to refine their strategy, we do not yet have adequate data to present the firm's expectations.

Evaluation Question 7: What lessons can be learnt about best practices in the design and implementation of agricultural pull mechanisms?

In order to answer this question, we asked potential implementers about their experience to date with the AgResults pilot or the market the pilot seeks to promote. These responses offer a number of insights that can be taken into consideration in the design of future incentive-based interventions. Several implementers expressed an interest in having the pilot play a role in a generic marketing campaign for improved OFS to help facilitate the development of a market by means other than a pull mechanism. Potential implementers also highlighted areas where their engagement in the market is currently constrained and where the pilot could, arguably remove constraints without benefitting any particular supplier. Examples include helping to facilitate or fast-track Kenya Bureau of Standards (KEBS) review of new OFS solutions and third-party testing of OFS solutions with results published in comparative fashion so that potential buyers or distributors could benefit from objective information about the options. Capital, both operating and investment, was an oft-cited constraint to involvement or expansion in the market. These issues merit attention as possible areas of learning for policy development as the pilot moves forward.

Next steps

Future evaluation reports will provide updated information on the baseline conditions after the intermediate survey is completed in summer 2015. A report after the final survey in 2019 is completed will provide information on the impact the pilot achieved. Based on the data collected in the next round, we will revise this baseline report to include updated baseline time trends incorporating the additional time point. We will also show projections for the key outcomes through the end of the pilot period based on time trends, which will serve as the counterfactual. We will also include the baseline time trend and the projections for food security. In addition, we will include the baseline trends of an unaffected or untreated outcome —maize yield—to remove any bias that arises from confounders that skew the unaffected outcome in a like manner to the affected outcomes as described in the evaluation design report.

Following baseline data collection, the evaluation team will also continue to monitor the pilot implementation as part of our ongoing qualitative assessment. This will consist of regular communications with the Pilot Manager, the Secretariat, DFID, and the Steering Committee to keep track of any issues that arise, their importance to the pilot's implementation, and how they are eventually resolved. This will continue up to the point of endline data collection in 2019 (assuming extension of the evaluation contract, as the pilot will run for three full years after it begins in 2015).

In or around May 2019, we will conduct the endline survey with the same sample of households surveyed at baseline along with qualitative data collection for other stakeholder groups. Based on this endline data collection, we will present an impact evaluation report by the end of 2019 addressing each of the evaluation questions. We will conduct a sustainability assessment in the spring of 2020, assuming extension of the evaluation contract.

1. Pilot design and implementation

This report discusses the findings of baseline research that Abt conducted in late 2014 for the AgResults on-farm storage (OFS) pilot in Kenya, which is designed to create a market for improved on-farm storage technologies appropriate for smallholders in the Eastern and Rift Valley regions of Kenya. This report presents the baseline conditions of both the OFS market and the smallholder farmer population being targeted by the pilot.

The report begins with this section outlining the motivation for the pilot and its theory of change enriched by Abt's initial qualitative research. It also provides details of the pilot's implementation to date and updates the information presented in Abt's evaluation design report (Abt Associates, 2014). Section 2 discusses the evaluation questions and methods used to address each question. Section 3 presents the survey sampling approach and sample characteristics for the baseline quantitative and qualitative surveys. Section 4 contains baseline findings relating to each key evaluation question. Finally, Section 5 concludes by summarizing the next steps for the evaluation.

1.1 The AgResults pilot objectives and theory of change

Kenyan farmers face extensive post-harvest losses of grain each season during storage, in large part because of the inability of commonly used storage facilities to combat pests, mould, and other problems. The AgResults pilot in Kenya is designed to increase the adoption of improved OFS by smallholders with the aim to reduce post-harvest losses of grains and increase the length of grain storage by smallholders, by creating a sustainable long-term market for storage solutions in Kenya. Current evidence suggests that post-harvest loss is high. Despite the need, currently the market for OFS products does not exist in Kenya due to the high investment costs associated with product development and distribution and lack of smallholder awareness about the benefits of OFS.

A study by the International Maize and Wheat Improvement Centre (CIMMYT; cited in Dalberg, 2012) found that traditional farm-level storage of maize led to losses of about 25% of the volume in Kenya, mainly due to weevils and the larger grain borer (LGB). The prospect of grain loss during storage is expected to drive economic losses: farmers tend to sell maize quickly after harvest when prices are depressed due to abundant supply, rather than waiting for prices to improve, in part because of the difficulty and expense of mitigating losses of stored grain. For the large majority of smallholders, most of these losses entail losing grain stored for household consumption. While smallholder farmers still keep most maize they produce for their own consumption, many end up buying maize back from the market when they exhaust that supply, usually at higher prices than they received when selling at harvest time the maize they grew. For farmers who are income constrained, the physical loss can also imply reduced consumption of grain with resulting adverse impacts on nutritional security. OFS that prevents losses, therefore, has the potential to reduce both physical loss of stored grain and economic and nutritional losses for farmers—an important motivation for the AgResults pilot as described in the pilot business plan.

Abt conducted an initial qualitative assessment (IQA) in Kenya to further understand the key constraints limiting the development of the market for OFS, and the potential risks and

opportunities that impact the AgResults pilot's success[1]. IQA results re-affirmed the business plan perspective that the low uptake of OFS is due to two related reasons. On the supply side there is limited availability of OFS products that are technically and economically appropriate for smallholders, and distribution networks to make the limited OFS technologies available to smallholders are weak. On the demand side, there is limited awareness among smallholders of the potential for OFS technologies to help them mitigate their post-harvest losses. More than their limited awareness about OFS, the binding constraints that limit smallholders' demand are likely to be the relatively high upfront costs of OFS products, farmers' cash constraints, and uncertain future benefits. The risk aversion and awareness gap among the potential demand pool (smallholder farmers) imply that entry of commercial distributors into the OFS market in Kenya will require significant upfront investment as well as intense and sustained marketing activities to persuade farmers of the benefit of the product. This adds to the already large investment cost OFS suppliers face to overcome the challenges in the distribution network.

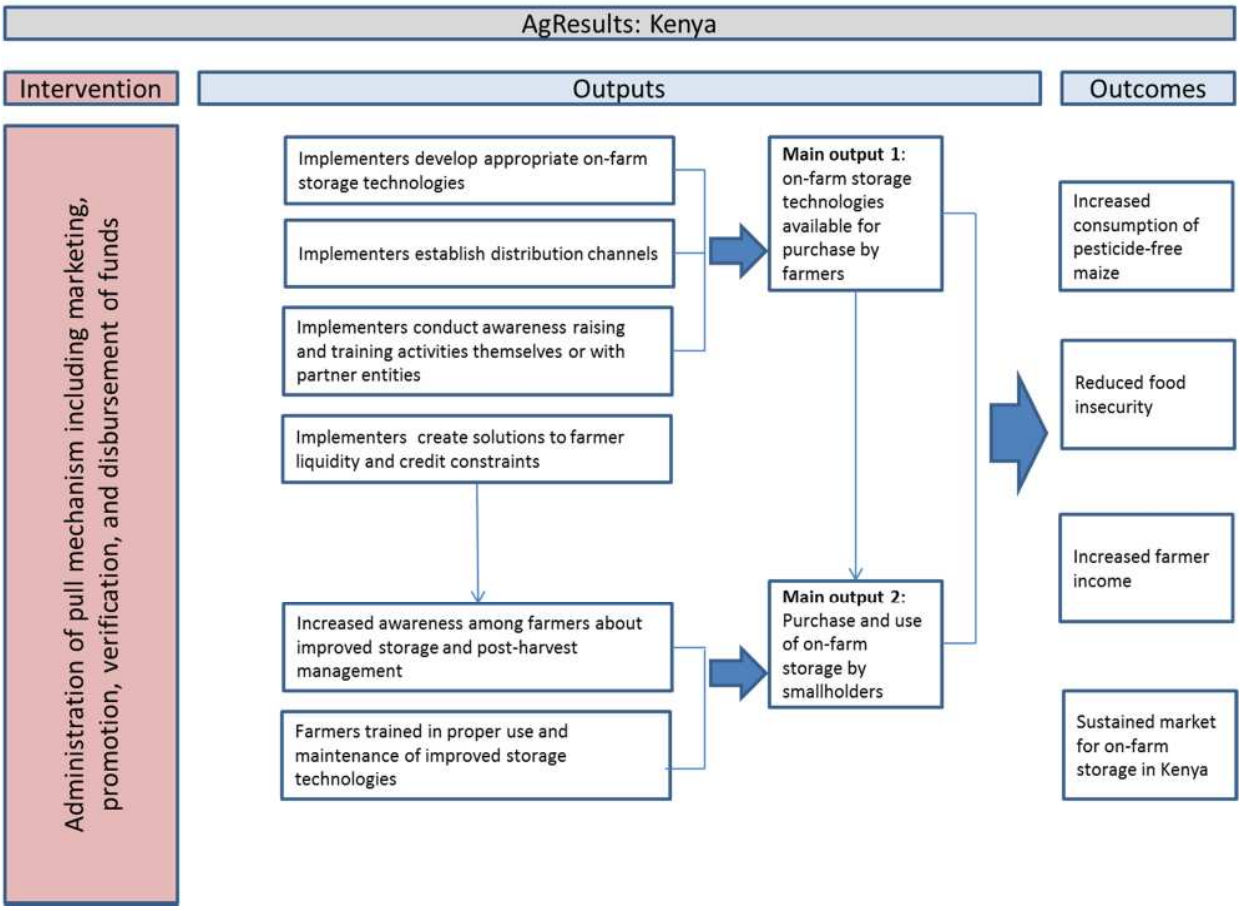
The AgResults on-farm storage pilot in Kenya aims to address these market failures for on-farm storage—supply-chain bottlenecks, lack of awareness, cash constraints, low working capital, or access to credit—by providing an incentive (in the form of a performance-based grant) to providers of improved storage technologies who can develop and sell sufficient on-farm storage volume to smallholder farmers.

Specifically, the pilot offers performance-based grant money to firms in proportion to the amount of technically appropriate storage that they sell. This is expected to motivate private sector investment in the market for on-farm storage solutions by technology providers. The theory of change, depicted in Figure 3, is that the performance-based grant mechanism will spur implementers to engage in development, distribution, financing, and awareness-creation activities that lead to a robust market for on-farm storage in Kenya. The creation of this market is intended to stimulate purchase of storage technologies by smallholder farmers that will ultimately improve farmer well-being as measured by outcomes such as food security and income.

Specific pilot provisions are intended to address important underlying constraints to development of the market such as the need for storage providers to enter the market at a scale sufficient to support the creation of a dynamic on-farm storage industry that will be sustained after the end of the pilot; to train farmers to utilize the storage appropriately and effectively; and to overcome the financial constraints that are understood to constrain farmers' ability to purchase storage. While storage providers have the autonomy to develop whatever distribution networks they feel are appropriate, it is expected that many will recruit existing agro-dealers—located on average within 8 km of farmers—to serve as retail outlets (Dalberg, 2012).

[1] The IQA was conducted in two phases, with the first phase involving a visit to understand the context of the pilot, and a second phase to understand the AgResults pilot implementation and logic through our evaluation design workshop. Both visits together contributed to our understanding of the constraints and opportunities to develop a market for OFS.

Figure 3. Theory of change for the Kenya AgResults pilot



These provisions recognize that simply putting storage on the market will not be sufficient to create sustainable demand and reduce farmers' post-harvest losses. For example, farmers must learn to use the storage properly, including techniques for adequate drying of grain prior to storage. Second, the storage must be economically accessible and beneficial to farmers, many of whom sell their maize at harvest time to pay school fees, loans, and other expenses and lack ready access to finance for significant purchases.

If the private sector is able to overcome the key market failures described above and create an effective market for on-farm storage in Kenya, resulting in increased adoption of OFS, there will be several benefits for smallholders. First, it is expected that post-harvest losses will be reduced for grains set aside for farmers' own consumption, implying that farmers will have greater stock of grain for lean periods, either for direct consumption or for sale to buy other food. Second, consumption of pesticide residue may be reduced because some new technologies eliminate the need for pesticide application during storage. Third, farmers may realize income gains of storing maize after harvest for longer and selling it at a higher price, instead of selling it right after harvest when prices are low.

The pilot design is tailored to the needs of each location where it will be implemented. In the Rift Valley region (defined within the pilot as comprising Uasin Gishu, Nandi, Trans Nzoia, Baringo, Laikipia, Kericho, Nakuru, Bomet, and Narok counties, roughly contiguous with the former Rift

Valley Province),[2] the focus is on the replication, distribution, and sale of existing technologies for maize storage. In the Eastern region (comprising Meru, Embu, Makueni, Kitui, and Machakos counties, roughly corresponding to the former Eastern Province), the focus is on developing and distributing smallholder-appropriate storage solutions that mitigate losses from the larger grain borer.

The Rift Valley is characterized as relatively well off and is responsible for well over half of Kenya's maize production on a yearly basis. Commercially oriented production is typical among large, medium, and small-scale farmers. Mechanized production and use of improved inputs are common, and there are credit facilities available to lend to farmers who qualify.

The Eastern region is poorer and suffers from inconsistent rainfall, drought, poor soils, and small and fragmented landholdings, such that maize yields are only about 40% of the national average (Government of Kenya, 2011, p.17). The counties in Eastern are generally considered to have poor agro-ecological conditions for maize, and several extension projects are working to reduce maize area planted in favour of other crops such as sorghum. Most maize-producing operations are conducted manually or with animal draught power, and the use of improved inputs is limited by their limited availability and lack of credit for their acquisition.

1.2 Evolution of pilot design and implementation[3]

Throughout its establishment and early implementation, the pilot has been subject to ongoing management decisions, many of which are administrative in nature but some of which either directly or indirectly involve or affect the pull mechanism. In this section, significant events in the evolution of pilot design are tracked and qualified, and the implementation process is summarized. This summary provides context to the analysis of results throughout the baseline report, and has particular relevance to the discussion of best practices and lessons learnt.

Initial pilot design

Pilot design as envisioned in the business plan (and to date) has two separate incentive structures, one to reward distribution of improved OFS in Rift Valley (primarily promoting marketing and adoption) and the other rewarding development and sale of LGB-proof storage structures in the Eastern region (simultaneously oriented toward research and development and adoption).

In Rift Valley, the focus is on the promotion and distribution of existing storage technologies; the goal is to encourage storage providers to develop effective and competitive marketing and distribution channels to deliver storage solutions to farmers. The Rift Valley incentive is structured in two stages. As envisioned in the business plan, Stage 1, during years 1-4, would lead to a prize of US$750,000 for each participant delivering 21,000 metric tons (MT) of on-farm storage capacity. Stage 2, implemented in year 4, consists of a proportional prize of up to US$1million to participants based on their relative contribution to overall storage capacity over

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[2] In 2013, Kenya began a rapid process of political devolution in which eight provinces were replaced by 47 counties, along with a number of other changes to governance structures. Accordingly, our evaluation uses the terminology of Eastern and Rift Valley "regions" and/or groups of "counties" to refer the two separate areas targeted by the pilot, in contrast to the pilot's original business plan (written before devolution), which refers to "Provinces."

[3] This section was developed in collaboration with Deloitte, the pilot Secretariat.

the four-year pilot. Any participant that meets the Stage 1 storage threshold of 21,000 MT storage capacity can participate in Stage 2. The goal of the two stages is to motivate participants to continue to fine-tune their strategy and increase scale over the life of the project, while also transitioning from a fixed-incentive to one that is dependent on performance in the market, as measured by relative sales.

For the Eastern region, the pilot's focus is on development of LGB-resistant technology, and it includes both R&D and a promotion and distribution component. The incentive offers a proportional prize of US$3 million to storage providers relative to their contribution of LGB-proof storage facilities to a minimum collective threshold of 21,000 MT storage. This incentive would be paid out in year 4 of the pilot.

In both cases, the pilot requires (and is responsible for) technical certification that the proposed storage solutions are "fit for purpose"; and specifies a maximum storage capacity to ensure that smallholder farmers are the main beneficiaries of the storage solution. The pilot also requires that the product be sold for at least the cost of production, and would not count sales to organizations or projects that would in turn distribute them to farmers on a subsidized basis or free of charge. Requirements for verification of sales were also outlined in the business plan, although not a specific verification process.

Evolution of the pilot design

Throughout the process leading to pilot implementation, a number of questions and issues arose, which led to revisions to the original incentive design or specifications where they were previously lacking. These include the following:

- Reduction of ambiguities in terms of definitions of the pilot. For example, refining the definition of a smallholder to one with land cultivation less than 5 hectares (12.5 acres).
- Increase in the maximum storage capacity threshold per device from 350 to 540 kg to allow participation of larger, more commercially minded farmers.
- Shift in 2014 to a three-year competition due to delays in Secretariat and Pilot Manager finalization of contracting mechanisms, exploration of the legal implications of the Kenya Gaming Act, the need to re-evaluate verification models, and the need to create an LGB-proof test due to the lack of a standardised test and implementers' inability to manage and fund the testing.
- Specification in approximately March 2014 of the pilot implementation area (and in the case of the Eastern region, broadening of the implementation area from just the Lower Eastern region) to focus on the following 14 counties:
  - Rift Valley Counties: Uasin Gishu, Trans Nzoia, Nandi, Nakuru, Laikipia, Baringo, Bomet, Kericho, and Narok Counties
  - Eastern Region Counties: Machakos, Makueni, Meru, Embu, and Kitui Counties.
- Limitation of the first Rift Valley prize of US$750,000 to "the first five Implementers to reach 21,000 MT Useful Life Adjusted Storage Threshold" rather than to all implementers that reach the threshold.
- Prizes are no longer staged into two phases, and implementers do not have to achieve Phase 1 by a certain time to qualify for Phase 2. That is, if implementers do not meet the threshold during the first stage, they can continue in the competition and qualify for the proportional prize providing that they meet the threshold during the second stage.

- Given the lack of international standards on LGB-proof testing, the Pilot Manager assumed responsibility for creating and implementing an LGB-proof test of competing storage products.

A major issue, whose resolution is ongoing at time of this baseline report, is the means by which sales will be verified. The business plan states that quarterly verification of sales will take place, with the implicit assumption that implementers are able to give adequately detailed and disaggregated sales data for all their buyers to support the verification process. This assumption has proved to be problematic as prospective implementers generally lack the capacity to trace or record every sale to end-users. At the time of the baseline report, the Secretariat has researched verification models and submitted the results of this research, along with a recommendation, to the Steering Committee for review.

Pilot development and implementation process

The pilot's development and implementation has taken place over an extended period, beginning with the development of the initial concept and business plan, the official version of which was published in May 2012. Various actors representing the AgResults Initiative, including the World Bank, Dalberg Global Development Advisors (Dalberg), and independent consultants, have been involved and interacted with the potential implementers as well as other organizations and firms that would potentially have a role to play in the pilot's implementation. In December 2012 and June 2013, Andrew Sergeant on behalf of the World Bank conducted a request for Expressions of Interest (EOIs) from prospective implementer companies. The AgResults Secretariat was established in July 2013; and in August 2013 it communicated with the companies that had submitted EOIs. The Secretariat then interviewed them during a visit to Nairobi in September 2013. Additionally, the Secretariat conducted a competitive bidding process to identify a Pilot Manager (PM), with award of that contract to Agribusiness Systems International (ASI) in February 2014.

Preparations for a launch of the pilot began following contracting of ASI and a formal launch event held in May 2014. At that point, responses to detailed questions that potential implementers had submitted were distributed in conjunction with a Request for Applications (RFA) from implementers. The RFA anticipated an official pilot start date of June 1, 2014, with accounting of sales to begin July 1, 2014. This timing would have allowed implementers to begin selling their products in time for the long rains maize harvest in Eastern (July-August) and the harvest in Rift Valley (October-January). During the pilot launch, however, prospective implementers raised a number of specific technical considerations that required resolution. Chief among these was the question of how sales would be verified, as discussed above. Although the RFA was active at that point, several firms expressed interest in delaying their application submission until they finalized their product offerings; sought Kenya Bureau of Standards (KEBS) and/or Pest Control Product Board approval of their products; determined their product rollout strategies; or awaited the resolution of pending issues, most notably the verification process.

During the October 2014 Steering Committee meeting, the Steering Committee requested that the pilot be put on hold while verification options were researched. In January 2015, the

Secretariat submitted a review of possible verification models[4] along with a recommendation to the Steering Committee. Following review and finalization of a verification process, verification organization(s) will be contracted by the Secretariat. Pilot implementers will be presented with an updated RFA that reflects updates to the pilot implementation process (particularly the process for qualifying storage solutions as LGB-proof and the verification process) and that will govern their participation in the pilot. Under the current timeline, sales for the competition are likely to begin on or about May 1, 2015.

2. Evaluation questions and methods

This section summarizes the evaluation framework and methods the Abt team is employing to evaluate the Kenya OFS pilot and test the assumptions outlined in the theory of change. Although the overall evaluation framework is the same for the two regions of pilot implementation, there are important differences in the incentive structures, implementation context, and expected impact (market penetration rates) for the Rift Valley and Eastern regions. Accordingly, much of our baseline assessment differentiates results across the two regions.

The Abt evaluation will assess whether the program has met its objectives and be guided by six out of the seven evaluation questions in the overall evaluation framework established by the evaluation design report (Evaluation Question 4 is not relevant for this pilot):

1. What has been the impact of the AgResults pilot on private sector engagement in the development and uptake of on-farm storage?
2. What has been the impact of the AgResults pilot on smallholders' uptake of on-farm storage?
3. What has been the impact of the AgResults pilot on smallholder income?
4. What is the impact of the AgResults pilot on consumers' demand for derivative products? *[not relevant for Kenya pilot]*
5. What evidence exists that the effects of the AgResults pilot will be sustainable in the medium to long term?
6. What is the evidence on the scale of any effect on private sector investment and uptake and on the cost-effectiveness of AgResults as an approach?
7. What lessons can be learnt about best practices in the design and implementation of agricultural pull mechanisms?

We will also address, within each of the questions, whether the pilot's impact is differentiated by gender or poverty status of beneficiaries, and analyse the determinants of any such effects that are identified. We use a mixed-methods approach to address each of the evaluation questions, with either a quantitative or qualitative approach predominating for each particular question and complementary qualitative or quantitative input to enrich the results.

Questions 1, 5, and 6 are related to the pilot's impact on the value chain and the value chain participants therein. The small numbers of value chain participants and multiple levels of interaction between the participants call for qualitative methods to answer these questions, which will allow for nuanced inquiry into the motivations of market actors, their strategies for

[4] These options included (1) a scratch sticker sales tracking system, (2) an agro-retailer incentive system to track sales, and (3) use of market surveys to determine market share and sales proportions.

engagement in the market, and the aggregate effects of their investments. Therefore, our evaluation assesses the market-level questions on the agenda (questions 1, 5, and 6) using primarily qualitative methods—specifically a structure, conduct, and performance (SCP) framework that is described in more detail in Section 3.1.

We use primarily quantitative (statistics based) methods to assess the pilot's impact on smallholder awareness, adoption, and use of on-farm storage solutions and subsequent effects on income (questions 2 and 3). Specifically, we employ a short interrupted time series (SITS) approach to estimate the impact of the pilot on smallholder farmers by comparing the pre-pilot time trend on key outcomes to post-pilot levels. The SITS design measures the intervention impact as a departure from the expected levels of the outcome measure (in this case smallholders' uptake of on-farm solutions and smallholder income) when projected forward in time, as an approximation of what would happen were the treatment not introduced (e.g., Shadish, Cook, and Campbell, 2002; Bloom, 2003). The SITS approach entails (1) generating a counterfactual for the outcome measure, which represents the expected level of the outcome in the post-intervention period in the absence of the treatment as the projected trend in pre-intervention observations of the outcome measure, and (2) modelling the treatment effect as a deviation of actual post-intervention outcomes from this counterfactual. Our qualitative research enriches and adds nuance to our understanding of the quantitative analyses of questions 2 and 3.

We address Evaluation Questions 5, 6, and 7 by drawing on and synthesizing the results of Evaluation Questions 1, 2, and 3. Table 1 presents these evaluation questions, which have been modified based on the expected impact of the pilot, along with the main method we use to answer the question.

Table 1. Evaluation questions and approaches

#	Evaluation Question	Evaluation Method
1.	What has been the impact of the AgResults pilot on private sector engagement in the development and uptake of on-farm storage?	Theory-based qualitative; SCP focused on the grain value chains for which the on-farm storage is relevant, particularly the maize value chain.
2.	What has been the impact of the AgResults pilot on the uptake of on-farm storage?	Impact evaluation using SITS supplemented by qualitative interviews.
3.	What has been the impact of the AgResults pilot on smallholder's maize revenue, and food security?	Impact evaluation using SITS supplemented by qualitative interviews for maize revenue, before and after analysis for maize consumption in lean season.
4.	*Not relevant for Kenya pilot.*	*N/A*
5.	What evidence exists that the effects of the AgResults pilot will be sustainable in the medium to the long term?	Synthesis of results from SCP and impact evaluation.

6.	What is the evidence on the scale of any effect on private sector investment and uptake and on the cost-effectiveness of AgResults as an approach?	Synthesis of results from SCP, with focus on market infrastructure and per-unit cost effectiveness of key outcomes from the impact evaluation.
7.	What lessons can be learnt about best practices in the design and implementation of agricultural pull mechanisms?	Compilation of results from all AgResults pilot evaluations.

3. Baseline survey and sample characteristics

This section describes the methods used for quantitative and qualitative baseline data collection and describes the data that were collected.[5] Given the pilot's expected start date sometime in 2015, we will conduct another survey—the intermediate survey—in mid-2015 to gather quantitative data on the 2014 seasons. We expect to update this analysis after the implementation schedule is finalized and the intermediary survey is completed.

3.1 Qualitative baseline methods and data

This section discusses the qualitative methods that guided data collection, the types of respondents from whom we collected data, the selection criteria, the number of respondents, the type of data we collected, and the process of data collection including the quality assurance measures that we took. The qualitative data contribute to the baseline assessment report in three areas. First, they underpin the testing of qualitative hypotheses about the private sector in the market for improved OFS (Evaluation Question 1). Second, they enrich interpretation of results of Evaluation Questions 2 and 3; and third, they contribute to the synthesis of results and hypotheses about the impact of the pilot and factors that will affect the development of the market for improved OFS, informing preliminary input to Evaluation Questions 5, 6, and 7.

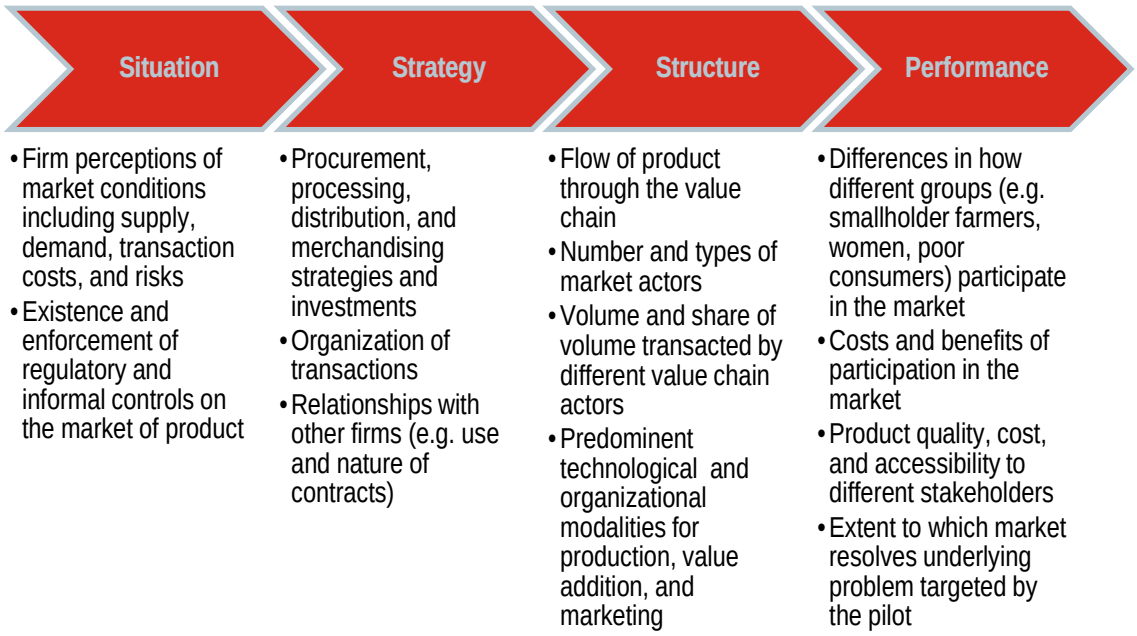
The qualitative baseline assessment was structured around a modified structure, conduct, and performance (SCP) framework. The SCP conceptual framework, which specifically addresses elements of Evaluation Questions 1, 5, and 6, is also broadly inclusive of the considerations and questions being addressed across the pilot as a whole, and as such was utilized to structure the overall qualitative data collection activity.

As described in the evaluation design report, the SCP paradigm examines interplay between the **basic conditions** of a market (such as supply and demand conditions and the institutional environment); individual firms' **strategies** regarding engagement in the market, which are a response to the firm's perceptions of the basic conditions; the market's **structure,** which is an outcome of the aggregated effects of individual firm behaviour; and the **performance** of the market. Thus, the specific analytical model actually reflects a causal flow from Situation (or

[5] Data collection for the quantitative analysis was conducted between July 18 and September 15, 2014,with the majority of the data collected by August 21, 2014. The qualitative analysis draws on the results of the Initial Qualitative Assessments as well as baseline data collection between May and November 2014.

basic conditions) to Strategy to Structure to Performance. Detailed explanation of each of these elements was provided in the evaluation design report and is summarized in Figure 4.

Figure 4. Structure-Conduct-Performance Conceptual Framework



Referencing the SCP framework, data collection focused on eliciting information on firms' and farmers' perspectives on the basic conditions underlying the market for improved OFS and on their strategies for engaging (or not) in the OFS market. Data collection also focused on characterizing the nature and scale of private sector engagement in the market, and obtaining a nuanced understanding of the factors that influence or are likely to influence the participation of specific groups of interest (such as women and the poorest farmers) in the market and their benefits from that participation. The qualitative analysis will assess the impact of the pilot as a whole on private sector engagement in the market and its impact on the development of a market for improved OFS products, making reference to the differential impact of the two different incentive structures (one for Rift Valley counties, and one for Eastern counties). In addition, the qualitative analysis will provide reflections on the gender-differentiated impacts of the pilot.

Sample size and sample selection

We collected the baseline data using semi-structured small-sample surveys of three types of actors in the market for improved OFS—current and potential suppliers of OFS (hereafter referred to as OFS suppliers), commercial distributors (wholesale and retail) of agro-inputs and agricultural hardware and equipment, and farmers. These three types are critical players in the value chain for OFS that was envisioned to emerge from the pilot, as articulated in the pilot business plan (Dalberg, 2012). Additionally, we also interviewed government actors, representatives of NGOs and development projects, and other experts with relevant knowledge about the implementation context and farm storage. Table 2 summarizes the interviews we conducted with each category of respondents, and how we selected the respondents.

Table 2. Qualitative sample by respondent type

Respondent Type	Sample Obtained	Sample Selection
OFS Market Actors		
OFS suppliers	7 current and potential OFS suppliers, 6 of which expressed interest in working on both regions. One focused exclusively on the Eastern region.	All potential OFS suppliers at time of May 2014 pilot launch event and all AgResults applicants as of January 2015.
Commercial distributors	46 distributors, 18 operating in Eastern and 28 in Rift Valley, with businesses headquartered in 40 of the pilot's 84 sub-counties and operations throughout the pilot area.	Representation of small-, medium-, and large-scale distributors; retail and wholesale orientation; and both male and female firm owners and respondents from nationally and locally active commercial agro-input and agricultural hardware distributors.
Farmers	72 farmers (30 in Eastern, 42 in Rift Valley) representing 24 sub-counties (2 per county) of all pilot counties except Baringo and Laikipia	Sub-counties selected to include those with medium and strong production of cereals and grains. Farmers selected to include representation of female-headed households (approximately 1 in 3), and diversity of commercial versus subsistence orientation and centrality versus remote locations.
Other Key Informants with Implementation Context and Farm Storage Issues		
Local government agricultural agents	Agents representing 53 out of 84 total sub-counties, all pilot counties.	Attempted one in each sub-county.
Non-profit (government, donor-funded, and non-governmental) organizations and projects	NGOs: 4 Universities/Research institutes: 2 Government agency respondents: 13	NGOs and development organizations/projects: CIMMYT, Caritas, Cereal Growers Association (CGA), Eastern Africa Grain Council (EAGC) Universities & research institutes: Tegemeo Institute, Purdue University Government agencies: County Directors of Agriculture, Agricultural Training Centre, National Cereals and Produce Board
Private sector players	Private firms: 15	Metal silo manufacturers, millers, private storage and warehouse receipt service providers, commercial agricultural lending firms

OFS suppliers: OFS suppliers are the firms that manufacture or procure and supply OFS products within Kenya, and organize their distribution to farmers; they include current and prospective AgResults implementers. Attempts were made to speak with all current and potential OFS suppliers. We interviewed six current and potential OFS suppliers to elicit information on their perceptions of the market for OFS, and their current and anticipated activities in the market

including what products they would market, how they would procure those products, and how they would distribute and promote the product and the role that the AgResults incentive played in those decisions. We drew additional insight from four AgResults implementer applications submitted prior to January 2015. (See Appendix B for the OFS supplier questionnaire.)

OFS suppliers interviewed included three firms that have been or are currently engaged in the market for improved OFS (GrainPro, Bell Industries, and KPMC), as well as three additional firms that were at different stages of preparing to enter or invest in the market (A to Z, Kentainers, and Vestergaard). OFS suppliers included both international and Kenya-based firms, and ranged in size from 20 to thousands of employees. Their portfolios also ranged broadly, from an exclusive focus on agricultural storage products and services to an array of manufactured products such as industrial storage bags and pesticide-treated mosquito netting. Finally, the firms' geographic scope of operations was likewise expansive and varied—while several firms were exclusively focused on Kenyan markets, the majority engaged in multiple African markets as well as markets on other continents.

In general, those firms that were not currently engaging in the market for OFS in Kenya had experience in related markets (such as agricultural equipment) or markets for crop storage products in other countries. The firms differed in their readiness to enter the market; whether they already had an improved OFS product ready to market, were undergoing the process of obtaining KEBS approval, had technical specifications of their anticipated product but were arranging manufacture, or were in the process of refining their product through their internal R&D processes.

Despite the great diversity of firms across the aforementioned parameters, the OFS suppliers interviewed were remarkably similar in their motivations to enter the market for OFS. In terms of motivations, respondents consistently expressed dual motivations to participate in the pilot and to enter the market for improved OFS in general—a business (profit-oriented) motivation, as well as a desire to help improve the livelihoods of smallholder farmers. All but one of the firms were interested in working in both the Eastern and Rift Valley regions; the lone exception intended to focus its activities in the Eastern region only.

Commercial distributors: Commercial distributors are those firms that were envisioned in the business plan to receive OFS products from suppliers and distribute them to farmers. These firms include both agro-input dealers and hardware stores that sell farm implements. They include national and regional-level wholesalers, as well as local retailers (most firms carry out both wholesale and retail sales, so the demarcation between wholesalers and retailers is a matter of degree rather than categorical). We selected commercial distributors based on the following criteria: First, they had to be active in the project's target area. Second, they were chosen to maximize coverage of the project's target area. Third, they were selected to achieve broad representation of the diversity in each respondent group. Therefore, we used purposeful sampling in which respondents represented a variety of scales of operation, market orientation, and gender.

National-level commercial distributors, whom we interviewed by phone, were identified from a roster that the Agricultural Economist consultant compiled from several business listings (including KickStart, Business List, Yellow Pages, and AMITSA). These interviews were later complemented by in-person interviews of local commercial distributors during field data collection. We interviewed a total of 46 commercial distributors to determine their awareness of

OFS issues that smallholder farmers face; their awareness of different OFS solutions; and their current or potential involvement in the market. We asked what types of OFS they would be most inclined to carry and how they would enter the market, including their procurement and merchandising strategies. (See Appendix B for the commercial distributors questionnaire).

Table 3 presents summary statistics of the characteristics of the 46 commercial distributors that we interviewed, of which 28 were from Rift Valley and the remaining were from the Eastern region. Respondents were primarily agro-input dealers, although several hardware stores and one association (Kenya Farmers' Association which operates a chain of retail outlets) were also captured. Nearly two-thirds of the respondents characterized their operations as primarily retail; the others had at least 50% wholesale sales. At least 20% of the outlets were owned by women, and 61% were owner-operated. Business operations ranged in size, with the vast majority having only one outlet and/or 1-2 employees; approximately 20% were classified as medium-scale operations with two or three outlets and between 3 and 10 employees, while approximately 8% had more than four outlets and 17% had more than 10 employees. The vast majority (85%) of commercial distributors interviewed sourced directly from importers or manufacturers or from other commercial distributors; the remainder purchased from intermediaries. Procurement source is important in the Kenya context for two reasons—first because of the proliferation of counterfeit products, which means that firms can only be assured of authentic products if they purchase directly from manufacturers or their authorized distributors; and second because those firms that source from local intermediaries are often smaller in scale and operate in more remote locations, with possible implications for their willingness or ability to stock OFS.

Table 3. Summary characteristics of commercial distributors interviewed

Location of operations	Mean	Count
Eastern	39%	18
Rift Valley	61%	28
Type of firm/organization		
Agro-input dealer	85%	39
Hardware store	13%	6
Association	2%	1
Does firm wholesale, retail, or both?		
At least half wholesale	39%	18
Primarily retail	61%	28
Female owner	20%	9
Female respondent	41%	19
Firm is owner-operated	61%	28
Firm is formally registered	98%	45
Firm size categories based on number of employees		
Small (1-2 employees)	61%	28
Medium (3-10 employees)	22%	10
Large (11+ employees)	17%	8

Location of operations	Mean	Count
Firm sized based on number of outlets		
Small (1 outlet)	72%	33
Medium (2-3 outlets)	20%	9
Large (4+ outlets)	8%	4
Where does firm obtain merchandise from?		
Direct from importers/manufacturers (e.g., Syngenta, Monsanto)	41%	19
Commercial distributor	46%	21
Intermediary (indeterminate sources)	15%	7
Total responses		**46**

Prior to asking specific questions about firms' perspectives on and engagement in the market for improved OFS (reported on in Section 4.1), firms were asked to qualify their understanding of on-farm storage issues that smallholders faced. Two-thirds of commercial distributors interviewed felt they were very informed about grain storage issues, and more than 90% were either very informed or somewhat informed. Most commercial distributors perceived farm-level storage losses to be a very severe problem, and all respondents agreed that they were at least significant. The most significant storage issues were perceived to be weevils, followed by LGB. The majority of respondents perceived theft, aflatoxins, bad post-harvest conditions, and rodents to be either minor issues or not issues at all. Awareness of farmers' storage issues seemed to be skewed towards those issues that can be addressed through use of chemicals or other inputs, possibly because these are the issues farmers most often discuss with commercial distributors.

Farmers: Farmers were interviewed to obtain insight into the factors underlying their use of and interest in alternative OFS solutions. Similar to the commercial distributors, farmers were selected for the qualitative interviews to maximize representation of the project's target area and to achieve broad representation of the diversity in each respondent group (see Table 4). We visited two sub-counties per county, focusing on those that were significant producers of cereals and grains (no visits were made to Baringo or Laikipia counties due to unsafe travel conditions); and we visited three farmers in each sub-county. In selecting farmers, we used purposeful sampling in which we sought respondents to reflect a variety of scales of operation, market orientation, and gender. We identified individual farmers on the basis of recommendations from commercial distributors, local government agents, and local community leaders during visits to the field.

The farmer interviews inquired into the types and severity of storage problems that farmers faced, their storage methods and exposure to alternative OFS solutions, their perspectives on what alternative storage methods would be of interest and how they would use them, and the reasons underlying these responses. Inquiry into farmers' exposure to and use of alternative OFS solutions were intended to help frame additional follow-up questions on what drove their activities or interests, enriching the understanding of the factors underlying the outcomes of interest. The open-ended questions were designed to elicit and capture farmers' particular perspectives and priorities, and to capture new and unanticipated responses that would not be possible in a structured survey setting. (See Appendix B for the farmer questionnaire).

Table 4[6] presents summary statistics of the characteristics of 72 farmers we interviewed, 30 of whom were in the Eastern region and 42 in the Rift Valley. Total area cultivated by farmer respondents averaged 2.7 ha, and ranged between 0.08 and 19.8 ha. Grains and cereals represented between 10% and 100% of total cropped area, averaging 71%. One hundred percent of respondents reported that maize was their most important grain/cereal crop, and 85% reported that they considered production for home consumption and market to be equally important, compared to 15% who produced primarily to satisfy their household requirements.

One-quarter of the households were female-headed (this was a reflection of the selection process, which deliberately sought out female-headed households), although women constituted more than half of the respondents on account of their spouses being unavailable in many cases. Respondents had very low rates of participation (only 4% of households interviewed participated) in agriculture-relevant organizations. Households that sold maize marketed approximately 61% of their output and received on average 2,475 Kenyan shillings (KES) per 90 kg bag.

Most farmers sold maize approximately one month after they harvested; nearly all farmers sold to traders on a cash basis with no prior arrangement. The primary motivations for sale were the need for cash for expenses (70%) including school fees (50%), while only 11% of the farmers reported that fear of storage losses motivated their sales.

Fifty-three percent of respondents stated that they never ran out of maize, while 33% ran out and had to purchase grain for their families' consumption. One-third of the households reported buying maize for the household's consumption at some point in the year, paying on average 3,327 KES per 90 kg bag, and reflecting an average sale-purchase price ratio of 74%. This average ratio, however, obfuscates the fact that prices vary widely among different locations and on a seasonal basis.

Table 4. Summary characteristics of farmer respondents by region

	Total		Eastern		Rift Valley	
	Mean	Count	Mean	Count	Mean	Count
Total crop area cultivated (hectares)	2.7	72	1.6	30	3.5	42
Share of cereal/grains in crop area cultivated (%)	71%	72	71%	30	71%	42
Share of harvest sold (%)	61%	43	52%	16	66%	27
Price received at sale (KES/90 kg. bag)	2,475.0	44	2,341.2	17	2,559.3	27
Household bought grain for home use after last major production season	33%	45	12%	17	46%	28
Price paid to purchase grain for household consumption (KES/90 kg. bag)	3,326.7	15	2,775.0	2	3,411.5	13

[6] These descriptive results are broadly consistent with the results of the quantitative survey. Divergences can be attributed to the purposeful versus randomized sampling methods used in the qualitative and quantitative data collection.

		Total		Eastern		Rift Valley	
		Mean	Count	Mean	Count	Mean	Count
Household members belongs to farmer organization or similar		4%	71	10%	29	0%	42
Gender of respondent							
	Male	44%	70	30%	30	55%	40
	Female	56%	70	70%	30	45%	40
Market orientation of household							
	Primarily grows maize and grains for household consumption	15%	72	13%	30	17%	42
	Grows maize and grains equally for household use and sale	85%	72	87%	30	83%	42
What motivated maize sale?							
	Payment of school fees	50%	43	40%	16	60%	27
	Cash for other expenses	70%	44	80%	17	60%	27
	Buyer availability	0%	44	0%	17	0%	27
	Payment of debts/loans	0%	44	0%	17	0%	27
	Attractive price	10%	44	0%	17	10%	27
	Fear of storage loss	10%	44	2%	17	0%	27

Local government agricultural agents: Though not directly engaged in the market for improved OFS, local government agricultural agents (particularly sub-county agricultural officers, or SCAOs) were interviewed as key informants in order to obtain an overview of the OFS issues, options, and utilization in each location. Their perspectives provided an opportunity to triangulate (verify) responses coming from other respondents, and also contributed to the determination of the OFS market structure. Questions to government respondents included asking them to qualify their awareness of storage issues in their sub-county, the severity of different types of storage issues, how farmers in the sub-county store maize and grains, and the sources of different storage options. Finally, we asked them to identify any projects or organizations that undertook activities that were relevant to OFS of grains and cereals; and provided them an opportunity to comment on or discuss the market for OFS in general and provide input on any additional questions they perceived to be relevant.

We attempted to interview at least one local government agricultural agent from each sub-county. Given that a directory of government agents is not publically available, we identified respondents by calling county-level District Agricultural Officers or by visiting sub-county agricultural offices during field data collection. We were able to interview representatives of 53 of the 84 sub-counties included in the pilot area. In the remaining sub-counties, we were not able to obtain the contact information of the appropriate respondents. The difficulty of obtaining such information has been exacerbated by the recent re-organization of Kenyan administrative units

from districts and locations to counties and sub-counties. (See Appendix B for the local government agent questionnaire).

Other key informants: Interviews of other key informants during the initial qualitative assessment also informed the baseline results. As outlined in Table 2, these key informants included representatives of NGOs and development organizations and initiatives such as Caritas (the development initiative of the Catholic Diocese), CIMMYT, and CGA; universities and research institutes such as Purdue and the Tegemeo Institute; government agencies including county directors of agriculture and the NCPB; and private sector players including artisans trained to manufacture metal silos, millers, private storage and warehouse receipt service providers, and commercial agriculture lending firms. Interviews with these key informants were broad and focused on characterizing storage issues that smallholder farmers face, the storage options that they use or have available and their strengths and weaknesses, and understanding how the market for OFS is affected by contextual factors such as trends in maize markets and agro-ecological conditions. The results of these interviews were presented in the IQA report and associated trip notes and are drawn on here (see Appendix C for a list of key informants interviewed).

Data collection and quality assurance

The first phase of data collection took place during the IQA in September 2013 and served to provide a broad perspective on the pilot implementation environment and farm storage issues. The second phase took place between May and November 2014, beginning with interviews of potential implementers during the AgResults launch workshop in May. We carried out phone interviews of government agents and national-level commercial distributors in June. Field-based in-person interviews of farmers, local government agents we had not reached during the phone survey phase, and local commercial distributors took place in October. For each type of respondent we developed semi-structured interview guides to collect the data. The interview guides contained a mix of closed form questions to allow for a basic characterization of the respondents and open-ended questions about the key OFS issues of interest (see Appendix B for the semi-structured interview guides). The in-country Agricultural Economist consultant collected the data through a mix of phone and in-person interviews with the exception of the farmer interviews, which were conducted exclusively in person. She recorded the in-person interviews only after obtaining the respondents' permission and in keeping with good practices such as ensuring confidentiality of participants' responses, maintaining respondents' personally identifiable data separate from their responses, and utilizing "naïve" questioning approaches to avoid introducing bias. The interview results were later transcribed into an online data entry template that allowed the Qualitative Lead to review the incoming data and provide timely feedback on any data collection or entry issues that were identified. Following completion of data entry for each type of respondent, the Qualitative Lead downloaded and cleaned the results before coding and analysis using SPSS. The Qualitative Lead interviewed implementer candidates in person.

We took important measures to ensure quality data. Prior to data collection, the Qualitative Lead trained the Agricultural Economist on the qualitative evaluation framework and approach, and worked jointly with her to pre-test and finalize the data collection instruments and protocol. The Qualitative Lead reviewed with the Agricultural Economist consultant good practices for qualitative data collection, and supervised initial implementation of the data collection

instruments and provided feedback as needed. Afterwards, the Qualitative Lead and Agricultural Economist consultant maintained regular communication during the data collection, allowing them to iron out implementation issues as they arose. These measures ensured that high-quality data were collected (e.g., relevant, replicable).

Data were analysed using descriptive statistics and pattern analysis with reference to the hypotheses outlined in the SCP analysis presented in the evaluation design report.

3.2 Quantitative baseline methods and data

This section discusses the quantitative baseline survey, its sample size, and the quality assurance measures taken in collecting the data. The quantitative baseline survey (see Appendix D for a summary of the topics covered in the interviews) was designed to support the short interrupted time series approach outlined in our evaluation design report for answering Evaluation Questions 2 and 3. Information from the baseline survey will also contribute to answering Evaluation Questions 5, 6, and 7.

SITS uses multiple pre-intervention data points to form a linear counterfactual trend of the key outcome variables by extrapolating the pre-project trend information into the post-intervention period. The multiple post-intervention data points, if they present a departure from this counterfactual, represent the impact. The key outcome measures that we are examining to answer Evaluation Questions 2 and 3 are smallholders' uptake of on-farm storage solutions, smallholders' income, and smallholders' food security as measured by number of months the stored grain is available for own consumption (hereafter referred to as food security). Since the pilot is expected to have little or no impact on cost of cultivation (other than the cost of OFS), instead of measuring the impact on smallholder income we focus on smallholder revenue, specifically on maize revenue because maize is the most important crop in the region. Furthermore, to understand the pathways to impact, we also consider the impact of the project on other intermediate outcomes such as smallholders' access to improved storage technologies, and smallholders' knowledge and attitudes about other storage practices that are essential for successful use of the technology. For example, if farmers do not dry or clean the grain properly, then the improved technologies will not be effective. These impacts are measured using a before and after analysis because building a time trend was not feasible using recall data for these outcomes.

Given our evaluation design, for each outcome measure, the baseline survey collected information on three pre-intervention observations, using retrospective questions to farmers concerning the 2013, 2012, and 2011 long rain harvest seasons. As noted above, because of implementation delays, we will conduct an intermediate survey to obtain information on the 2014 harvest seasons, which will be the last pre-intervention observation before the pilot implementation begins. Later, at the endline, we will gather information on three post-intervention observations (2015, 2016, and 2017) to complete the impact analysis as described in the evaluation design report. We also collected information on additional outcome measures for just the 2013 harvest season (awareness of the benefits and correct use of OFS, knowledge and attitudes about other storage practices). For these outcome measures we will conduct a before and after analysis.

In addition to the outcome variables, we also collected information on household and village characteristics, which are important covariates to control for when estimating the trend.

Specifically, to form the counterfactual trend, we estimate the regression equation below, separately for the Eastern region and the Rift Valley. We use a linear specification to measure the trends in outcomes for the years 2011 through 2013, and use county fixed effects and village and household random effects[7].

(1) $Y_{thjk} = \beta_0 + \beta_1 time_t + \sum_{n=1}^{N} \beta_{n+1} X_{hjk}^{n} + \sum_{m=1}^{M} \beta_{N+1+m} W_{jk}^{m} + \sum_{r=1}^{R-1} \beta_{N+M+1+r} C_k^r + \mu_{jk} + \delta_{hjk} + \epsilon_{thjk}$

where:

Y_{thjk} = Outcome measure for household *h* in village *j* in county *k* at time *t*.

$time_t$ = The counter for observations, and time = *t* = 1, 2, and 3 denote the three pre-intervention periods (years 2011, 2012, and 2013).

C_k^r = Indicator (i.e., fixed effect) for county *r (r = 1, 2,…, R).* It equals 1 if *k* = *r* and zero otherwise. We include *R-1* counties in each of the two regions to control for time-invariant differences between counties.

X_{hjk}^{n} = The n^{th} characteristic of the household *h* in village *j* in county *k* (includes head of household information on gender, age, education level, literacy; household information on number of members in the household, whether a family member lives outside of the village, "very poor" status as defined by USAID, total area of all owned plots, labour and input expenditure, plot irrigation, time spent on farming, need for loans, and total labour income). These characteristics are current as of 2013, and are considered to be time invariant.

W_{jk}^{m} = The m^{th} characteristic of village *j* in county *k* (includes distance to the nearest motorable road, tarmac road, main market, nearest agricultural extension office, and matatu/bus stop). These characteristics are current as of 2013, and are considered to be time invariant.

μ_{jk} = Random effect for village *j* assumed to be distributed with a mean of zero and variance of σ_μ^2. This variance term captures the outcome variation across villages within a given county.

δ_{hjk} = Random effect for household *h,* which is assumed to be distributed with a mean of zero and variance of σ_δ^2. This variance term captures the outcome variation across households within a given village.

[7] In this model, county effects are modelled as fixed because all counties are represented in the survey sample, while the village and household effects are modelled as random to reflect the sampling variability introduced by the sampling carried out at these levels. In Equation 1, β_1 captures the linear time trend in the outcome measure (which is essentially based on the change in the outcome measure during the baseline period).

ϵ_{thjk} = Residual associated with observations at time *t*, which is assumed to be distributed with a mean of zero and variance of σ_ϵ^2. This term captures the variation in the outcome measures of a household across time.

Accordingly, the AgResults Kenya baseline survey included 16 modules designed to collect data on all outcomes of interest as well as household-level and village-level covariates included in *W* and *X*. Appendix D provides a summary of each survey module.

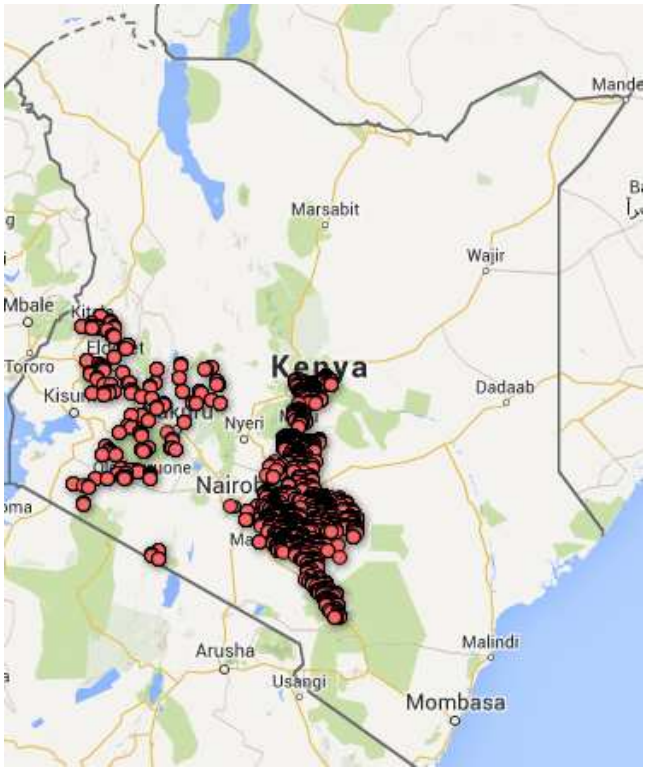
We present disaggregation of results by the gender of the household head and by poverty status of the households measured using the Poverty Assessment Tool (PAT) developed by USAID, which identifies a set of variables that serve as a proxy for poverty. We elected to provide disaggregation by poverty status rather than other variables proposed in the evaluation design report—ownership of land, degree of credit constraint, level of education, household size—because the ultimate intent of disaggregation by these variables was to identify the poor households. Use of PAT is an improvement over this approach.

Sample size and sample selection

We collected information on key outcomes and covariates from a total of 4,765 smallholder households across the pilot's 14 target counties (see Appendix F for details of the power analysis that determined that sample size). Our sample size was based on statistical power analyses to estimate the number of villages and households that would be needed in the evaluation sample to be able to detect the expected impact with reasonable statistical power under the analysis approaches described above. The sample size requirement is determined based on the first outcome—uptake of storage, which is the most proximal outcome that the pilot aims to influence. Since the two regions in which the AgResults pilot works are different, and the anticipated penetration rates of OFS in the two regions are different, we conducted separate power analyses to arrive at the needed sample sizes for the two regions to detect an increase in the adoption rate of OFS based on the AgResults Kenya Pilot Business Plan (Dalberg, 2012). The anticipated penetration rate is 6% and 18% in the Eastern region and the Rift Valley region, respectively. Accordingly, in the Eastern region, where the expected penetration rate is small, implying a smaller expected average impact, we sampled 4,140 households (5 counties with 138 villages per county, and 6 households per village). In the Rift Valley we sampled 540 households (all 9 counties, 10 villages from each selected county, and the sampling of 6 households from each selected village). These sample sizes would also allow a minimum detectable impact of 16% market penetration in the Rift Valley and 6% market penetration in the Eastern region.

In each county of the two regions, survey areas (sub-counties) were purposively selected based on their likelihood of being targeted by implementers for marketing and sale of improved OFS technology based on (1) sub-county level maize production and yield data and (2) implementers' own indications of which areas they planned to target as stated in their applications. As noted, we sampled 10 villages from each county in the Rift Valley, and 138 villages in Eastern counties. The villages were randomly selected from a list of villages compiled from the 2009 Kenya census. Figure 5 shows a map of surveyed households.

Figure 5. Mapping of surveyed households



At least six households were sampled from each village. (The sampling plan called for six households per village, though in a handful of cases more households were sampled.) Survey enumerators used a random walk to select households, starting from a geographic landmark such as a main road junction or a permanent structure such as a church or bridge, and followed a pre-determined skipping interval. In most cases, this interval was five, but in some villages where households were particularly far apart, a lower skipping interval was used. Survey enumerators then screened households based on two criteria to ensure that the impact evaluation targets the same population as the implementers so as to accurately capture the true change in outcomes for the targeted population:

- The target household must have grown at least one crop in 2013 (the year for which data were being collected) that could be stored in an improved OFS container. The qualifying crops were barley, beans, cowpeas, green grams, maize, millet, njahi (a type of black bean), pigeon peas, and sorghum.
- The target household must have cultivated no more than 20 acres (in Eastern counties) or 35 acres (in Rift Valley counties). The purpose of this cut-off was to exclude "large" farmers from the sample, as AgResults targets smallholders[8].

[8] There was disagreement among various experts and officials at the Kenyan Ministry of Agriculture as to what amount of land holdings qualifies small versus medium or larger farms. Furthermore, at the time of the survey the AgResults pilot team had not yet determined the cut-off to be considered a smallholder. The Abt team's earlier qualitative research also indicated that slightly larger and/or wealthier farmers may be more able and willing to buy improved OFS than truly "small" farmers. As such, the cut-off was set such that all small- to

Data collection and quality assurance

Research Solutions Africa (RSA), a Kenyan research and survey firm contracted by Abt through a competitive bidding process, conducted the baseline survey in July and August 2014. RSA reviewed, translated, and facilitated pre-testing of the survey questionnaire with farmers similar to those in the AgResults target counties. They also scripted the survey instrument for mobile data collection using SurveyToGo on Android phones. Once the survey instrument was finalized, RSA recruited and trained (with Abt's participation) a group of 51 survey enumerators. Training included familiarization with the questionnaire (including explanations of the motivation behind each question by the Abt team), practice with the mobile data collection template, mock interviews, and field-based pilot interviews with actual farmers.

During fieldwork for the main survey, the pool of enumerators was split into teams of five (four enumerators and one supervisor) and dispatched to various target counties. Where possible, teams included at least one member fluent in the common language spoken in the team's assigned county. Most interviews were conducted in Kiswahili, 92 were conducted in Kalenjin (the common language in Rift Valley counties), 662 were conducted in Kamba (the language spoken in some Eastern counties), and 156 were conducted in English. The questionnaire was available on enumerators' mobile devices in English, Kiswahili, and Kalenjin. For interviews conducted in Kamba, enumerators conducted simultaneous translation and entered data using the English or Kiswahili version of the template.

Both RSA and Abt employed quality assurance procedures to ensure data quality. First, the data entry template was pre-programmed with skip logic and range checks to limit the potential for data entry error on the part of the enumerators. During data collection, RSA team supervisors and managers spot-checked interviews and scrutinized all data on a daily basis, performing call-backs when errors were found. RSA's data manager compiled and submitted data to Abt on a weekly basis. The Abt team then performed a number of consistency checks and checks to make sure the sampling plan was followed correctly. Abt also employed three independent back-checkers who visited about 10% of the households surveyed within one to three days of the original interview to re-ask a selection of survey questions. These data were then transmitted to Abt directly and compared against the original interview to ensure an acceptable level of data accuracy[9]. RSA then took appropriate action to correct errors, including call-backs to rectify inconsistent or illogical information, replacement of erroneously sampled households, and dismissal of one enumerator who was found to be fabricating data (all data collected by this enumerator were then thrown out, and those households were replaced in the sample).

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medium-scale farms would be included in the sample. A higher cut-off was set in the Rift Valley because farms there tend to be larger on average.

[9] Overall agreement between original interviews and back-check interviews averaged roughly 80%. Most questions with lower agreement rates pertained to household asset inventories (e.g., livestock, small household durable goods). Questions pertaining to outcomes of interest and other key variables tended to have a higher rate of agreement overall. Internal consistency (i.e., logical consistency between different questions in the same interview) was found to be very high; variables we examined had internal consistency of 95% or higher on average.

RSA performed a first round of data cleaning to correct for common error types such as unrealistic values and remaining inconsistencies in survey responses using SPSS software. The Abt team then finalized the data cleaning using Stata software.

Sample characteristics

This section presents household-level descriptive statistics of the households sampled in the baseline survey. It begins with a description of basic household characteristics, followed by farming characteristics such as land area cultivated and crop mix, followed by a more detailed discussion on maize (and other grain/pulse) production including current post-harvest maize handling practices and storage facilities. We report all characteristics separately in the two regions targeted by the pilot. Baseline results on key variables are generally in line with findings from other agriculture-focused surveys conducted in Kenya in recent years (e.g. Kibara et al. [2009], Mwangangi et al. [2012], and Government of Kenya [2005/6]). We have included a brief note in instances where our results differ meaningfully from others.

Household characteristics: Twenty-three percent of the households in the Eastern region and 17% in the Rift Valley region were female-headed (see Table 5), slightly lower than the proportion of female-headed households found in the 2005-6 Kenya Integrated Household Budget Survey (31.0% in the Eastern region and 26.3% in the Rift Valley region) but higher than the proportion found in Kibaara et al. (2009) (12% or less overall). Eastern households had an average of 5.1 members (2.2 of whom worked in the past 12 months, meaning their primary occupation was an income-generating activity such as salaried labour or work on the household farm), while Rift Valley households tended to be larger with 6 average members (and 2.2 average working members). Female-headed households in both regions tend to be slightly smaller (4.7 members in the Eastern region and 5.4 members in Rift Valley) and to have fewer working members (1.9 in both regions). Household heads are just under 51 years old on average in the Eastern region and just under 48 in Rift Valley, with female household heads tending to be slightly older (54.2 in the Eastern region and 50.5 in Rift Valley) than male household heads (49.4 in the Eastern region and 47.5 in Rift Valley). Reflecting Kenya's relatively high overall literacy rate, 82.5% of household heads in the Eastern region sample are literate, and 85.4% in the Rift Valley sample are literate. However, there is a significant gender disparity: in the Eastern region, male household heads have an 87.9% literacy rate, while female household heads have a 64.7% literacy rate. In the Rift Valley, male household heads have an 89.6% literacy rate, and female ones have a 64.4% literacy rate. This disparity could have significant implications for women's ability to access and understand information about new storage technologies introduced under the AgResults pilot. In the Eastern region, 18.9% of households have at least one member who lives outside of the household in order to work and contribute income, and in the Rift Valley 27.2% do. Earlier qualitative research suggests that having at least one member living and working away from the homestead could increase the household's access to resources and information, which could affect adoption of OFS.

Table 5. Household characteristics

	Eastern			Rift Valley		
	Total	Male HH head	Female HH head	Total	Male HH head	Female HH head
Household head is female	23.5%	-	-	16.8%	-	-

	Eastern			Rift Valley		
	Total	Male HH head	Female HH head	Total	Male HH head	Female HH head
No. of household members	5.1	5.2	4.7	6.0	6.1	5.4
No. of working household members	2.2	2.3	1.9	2.2	2.2	1.9
Household head age	50.6	49.4	54.2	48.0	47.5	50.5
Household head literacy	82.5%	87.9%	64.7%	85.4%	89.6%	64.4%
At least one household member lives full or part time in other city for work	18.9%	19.9%	15.6%	27.2%	28.1%	22.8%
Total area of all owned plots (ha)	1.2	1.3	1.1	1.7	1.8	1.4
Total area of all rented-in plots (ha)	0.1	0.1	0.1	0.2	0.2	0.1
Total household income (KES)	218,994	235,907	163,866	197,510	216,016	105,781
Net farm income 2013 (KES)	42	468	(1,348)	10,982	12,520	3,359
Labour income in past 12 months (KES)	218,952	235,438	165,214	186,528	203,497	102,422
Household is "very poor" according to Poverty Assessment Tool[1]	31.0%	32.6%	25.7%	53.3%	54.2%	48.9%
Religion						
Christianity	99.1%	99.0%	99.5%	98.5%	98.2%	100.0%
Other	0.9%	1.0%	0.5%	1.5%	1.8%	0.0%
Ethnicity						
Kamba	59.1%	57.9%	63.2%	0.2%	0.2%	0.0%
Meru	20.5%	21.6%	17.0%	0.0%	0.0%	0.0%
Kalenjin	0.2%	0.1%	0.4%	65.1%	66.2%	59.8%
Kikuyu	1.2%	1.2%	1.2%	13.1%	11.8%	19.6%
Other	19.0%	19.2%	18.2%	21.6%	21.8%	20.6%

[1] The USAID Poverty Assessment Tool is a poverty scorecard designed to estimate poverty levels among groups of people. Kenya's PAT was developed using the Kenya Integrated Household Budget Survey (KIHBS) 2005/6. The tool comprises a short set of indicators which, when combined, create a score that is highly correlated to extreme poverty as measured through income and consumption in the KIHBS (US$1.25 per day per capita).

Households own, on average, 1.2 hectares (ha) of land in Eastern and 1.7 ha in Rift Valley (again there is a slight gender disparity, with female-headed households owning several tenths of a hectare less than their male counterparts in both places). Renting-in land is not particularly common; Eastern households rent-in only 0.1 ha of land, and Rift Valley households rent-in 0.2 ha on average.

Average household income (calculated as crop sale income and off-farm income, but not including sales of assets) for smallholders during the reference period (2013 agricultural cycle plus most recent 12 months of wage/labour income) was KES 218,994 in the Eastern region (about US$2433 at the current exchange rate) and KES 197,510 in Rift Valley (about US$2195). In both regions male-headed households had significantly higher incomes than female-headed ones (KES 235,907 on average for male-headed households in the Eastern region and KES163,866 for female-headed ones; in the Rift Valley region, KES 216,016 for male-headed households and KES105,781 for female-headed ones). The vast majority of this income, on average, comes from household labour (KES 218,952 in the Eastern region and KES 186,528 in the Rift Valley region) rather than agricultural revenue (only KES 42 in the Eastern region and KES10,982 in the Rift Valley region), indicating that, while these are farming households, the norm is subsistence rather than commercial agriculture. Results on total household income and sources of that income elsewhere in the literature vary widely, though the total income figures reported here are well within the range of other findings. The only substantial difference was that this baseline survey's results show a higher contribution of off-farm income to total household income than do other surveys (e.g. Kibaara et al. [2009], which shows crop income making up more than 35% of household income in maize growing regions). (Net farm income was even negative for one sub-category—female-headed households in the Eastern region had KES -1348 in farming income for 2013; this indicates that they spent more on labour and farming inputs than they received from crop sales)[10].

Thirty-one percent of sampled households in the Eastern region qualify as "very poor" according to their Poverty Assessment Tool score, bringing them roughly in line with the Kenyan average. The Rift Valley sample has a higher poverty rate (53.3%). Surprisingly, female-headed households in the sample have a slightly lower extreme poverty rate (25.7% in the Eastern region and 48.9% in the Rift Valley region) compared to male-headed households (32.6% in the Eastern region and 54.2% in the Rift Valley region). These PAT scores should be interpreted with caution, especially given the somewhat surprising poverty levels assessed for Rift Valley (according to PAT documentation, the overall tool-predicted poverty level for Kenya at the time of the tool's development was 36.6% [USAID, 2010]). First, this model is designed to predict poverty status with 79% accuracy, a making it a good but not perfect prediction tool. Second, since the PAT is developed using nationally representative data, its accuracy is reduced when using it for a smaller area. Given the comparatively small Rift Valley sample, the results for that region in particular may lack precision. Finally, some of the measures used by the tool may simply be out of date, as the tool was constructed based on 2005/6 data. However, regardless of these caveats, we feel this indicator of poverty status remains a useful overall tool to help

[10] Note that, for reasons of interview brevity, the survey did not ask respondents to report on income from asset sales, which are also a source of income for rural households. For this reason, households may actually take in more money per year than the data here indicate. This could also explain why we do not see higher incomes in the Rift Valley than the Eastern region.

describe initial conditions at the household level as well as to assess later on whether there are differential impacts of the pilot based on household poverty status.

The vast majority (about 99%) of households interviewed in both regions identify as Christian. Very few said their religion was Islam, traditional, or none. In terms of ethnic identification, a majority of Eastern households (59.1%) identify as Kamba, with 20.5% identifying as Meru and 19% as other. In the Rift Valley, 65.1% of households identify as Kalenjin, 13.1% identify as Kikuyu, and 21.6% identify as other.

Households in both regions tend to be located less than 1 km from the nearest motorable road, averaging 0.4 km in the Eastern region and 0.8 km in Rift Valley (the exception being female-headed households in the Rift Valley, who are an average of 1.6 km from the nearest motorable road). The distance to a tarmac (paved) road is substantially higher at 10.8 km in the Eastern region and 9.8 in km Rift Valley. Households in the Eastern region travel a much shorter distance to the nearest matatu (bus) stop (3.8 km on average) compared to Rift Valley households (6.9 km on average). Households are relatively far away from main markets (defined as a market where people from multiple villages congregate to buy and sell, in contrast to a local or village market). In the Eastern region, households travel 8.9 km on average to access the nearest main market, and in the Rift Valley they must go slightly further, 10.7 km on average (see Table 6). Agricultural extension offices tend to be 9.7 km away in the Eastern region and 12.8 km away in the Rift Valley. Proximity (or lack thereof) to an agricultural extension office may indicate the relative difficulty farmers face in accessing agricultural information and advice.

Table 6. Distance to key places (km)

	Eastern			Rift Valley		
	Total	Male HH head	Female HH head	Total	Male HH head	Female HH head
Motorable road	0.4	0.4	0.5	0.8	0.7	1.6
Tarmac (paved) road	10.8	10.7	11.0	9.8	9.6	10.6
Matatu/bus stop	3.8	3.8	3.8	6.9	6.7	8.0
Main market	8.9	8.9	9.0	10.7	10.8	10.2
Agricultural extension office	9.7	9.7	9.5	12.8	12.8	13.1

Farming characteristics

This sub-section discusses key farming characteristics of households, including plot and crop inventories, labour, input expenditure, current storage facilities, and awareness and adoption of improved OFS technologies.

As shown in Table 7, cultivated area for Rift Valley households tends to be slightly larger (1.2 ha) compared with Eastern households (1.1 ha). Eastern households, however, experience a short rainy season in addition to their main season (refer to Appendix A for information on seasons for each region). Eastern households reported that they tend to plant slightly less area (1 ha on average) during the short rainy season than in the long one.

Table 7. Land cultivated

	Eastern			Rift Valley		
	Total	Male HH head	Female HH head	Total	Male HH head	Female HH head
Land cultivated, long rainy season 2013 (ha)	1.1	1.1	1.0	1.2	1.2	1.1
Land cultivated, short rainy season 2013 (ha)	1.0	1.0	0.9	-	-	-

* Note: short rainy season applies to Eastern households only.

Farmers reported cultivating a fairly limited mix of crops in the 2013 growing season or seasons. Figure 6 shows the percentage of farmers growing various crops during the 2013 long rainy season (crops grown by less than 5% of households are not shown). Maize and legumes commonly consumed with it (such as beans, cowpeas, and pigeon peas) were grown by many households. This is unsurprising, given the maize-rich Kenyan diet (and given that households were screened based on whether they grew any of nine grain and pulse crops that can be stored in improved OFS technologies).For the most part, there was little variation between male and female household heads (see Appendix G for a gender-disaggregated crop mix table). Maize is by far the most popular crop, grown by 98% of Eastern households and close to 100% of Rift Valley households, while common beans were second in both regions (grown by 73% of Eastern households and 66% of Rift Valley households). Cowpeas are grown by far more farmers in the Eastern region (41%) than in the Rift Valley (3%). Pigeon peas are also popular in the Eastern region (35%), as are green grams (22%); each of these crops is grown by less than 1% of Rift Valley farmers. Rift Valley farmers are more likely to grow Irish potatoes (12%) compared to Eastern farmers (1%). Millet is grown by just under 6% of farmers in both regions. Njahi, rice, banana, coffee, and miraa (khat) are all grown by between 3% and 5% of farmers overall. All other crops were reported as being planted by less than 3% of the sampled households. Sorghum and barley, which can be stored in improved OFS technologies but are not commonly consumed in Kenya, were grown by virtually none of the farmers in the 2013 long season.

Figure 6. Crop mix, long rainy season 2013

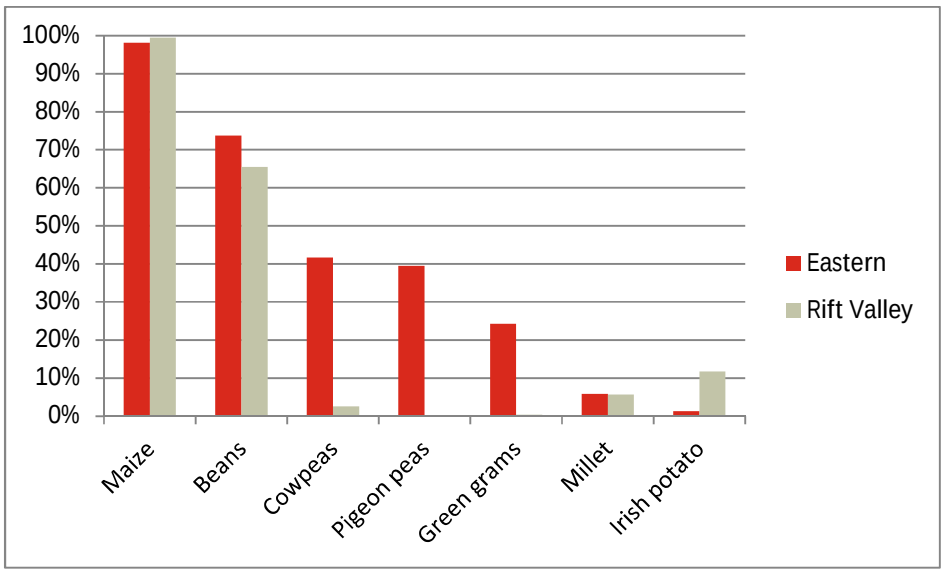
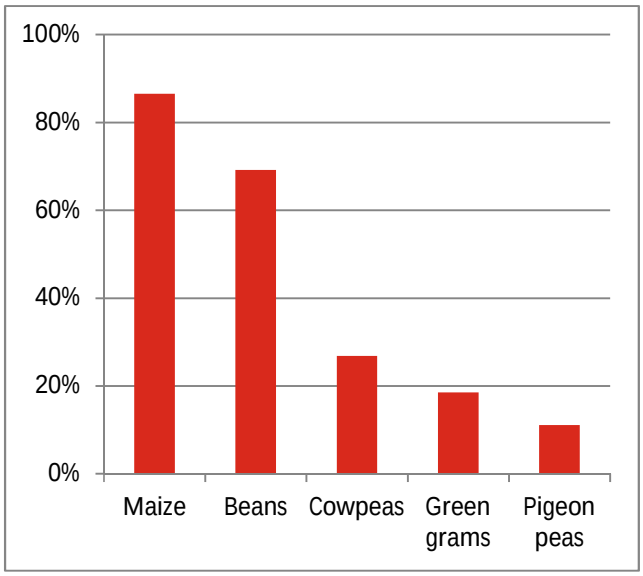


Figure 7 shows the crop mix practiced by farmers in the sample in the Eastern region during the 2013 short rainy season. These crops closely resemble those grown in the long season, indicating that farmers tend to plant the same crops twice per year. Maize was again the most popular (grown by 87% of households), followed by beans (69%), cowpeas (27%), green grams (19%), and pigeon peas (11%).

Figure 7. Crop mix, short rainy season 2013 (Eastern only)



Because the AgResults pilot aims at maize and other crops that can be stored, the baseline survey asked a more detailed set of questions about farming practices for these crops. These data are presented in the next section of the report. Because nearly all households grow maize and because it is the staple food in Kenya for which farmers are most likely to purchase improved OFS technologies, survey enumerators asked the more detailed set of questions first about maize

and then about one other crop, defined as the storable cereal or pulse crop grown on the largest amount of the household's cultivated land after maize from the following list: barley, beans, cowpeas, green grams, millet, njahi, pigeon peas, and sorghum. (In less than 2% of cases, households did not grow maize, and in those cases enumerators asked about the top two non-maize storable cereal or pulse crops.) The cereal/pulse crops farmers reported growing on the most land area after maize are presented in Table 8.

Table 8. Percentage of households reporting they planted significant land area with other cereal/pulse crops

Crop	Eastern	Rift Valley
Barley	0.0%	0.0%
Beans	61.8%	65.1%
Cowpeas	12.6%	0.9%
Green grams	8.9%	0.0%
Millet	1.5%	1.8%
Njahi	0.0%	0.0%
Pigeon peas	6.4%	0.0%
Sorghum	0.0%	0.0%

Summary of gender-differentiated characteristics

As discussed throughout the preceding text, there are significant differences in the demographics and socio-economic status of male and female-headed households in the Eastern region and the Rift Valley region. These are summarized here. Across both regions, women household heads tend to be older and less literate than male household heads. Additionally, women-headed households have fewer household members, fewer working members, and less access to the resource flow that can be provided by having a household member living and working in another city. Economically, women-headed households appear to be significantly worse off, with less land to cultivate, and much lower farm income, labour income, and total income (Table 5). With few exceptions (such as distance from main market), women-headed households tend to be more physically isolated than male-headed households. This is even more strongly the case in Rift Valley than in Eastern (Table 6).

There are also significant regional differences among women-headed households. Compared to Rift Valley, women-headed households in the Eastern region have older household heads, and much less likelihood of having a family member living and working in another city. They tend to be much more heavily dependent on labour income than women-headed households in Rift Valley and, despite their negative farm income on average, they have higher total household incomes and are less likely to be "very poor" than female-headed households in Rift Valley (Table 5).

4. Baseline findings on evaluation questions

4.1 Evaluation Question 1: What is the impact of the AgResults pilot on private sector engagement in the market for on-farm storage?

In this section, following the SCP analytical framework, we outline the baseline conditions of the market for OFS, beginning with OFS market players' perceptions of the basic (underlying) market conditions, then their strategies in the market given these conditions, and the aggregate market structure and market performance. For each major type of OFS market player (farmers, OFS suppliers, and commercial distributors), we discuss the current situation then delve into their likely engagement in the market once OFS suppliers involved in the AgResults pilot begin their promotion and distribution activities. The results draw on the interviews with the OFS market players themselves, and other key stakeholders as described in Section 3.1 above.

Basic market conditions for OFS

The basic conditions of the OFS market, which drive decisions of whether and how to invest in the market (firm strategy) are described below, beginning with the perceptions of OFS market players (farmers, OFS suppliers, and commercial distributors) of the OFS market and its potential, and their interest in engaging in the market. Prior to baseline implementation, it was hypothesized that farmers faced severe storage constraints, but there was limited awareness, availability, and use of improved OFS solutions that had the potential to reduce the storage losses faced by smallholders. Baseline findings supported these hypotheses.

OFS suppliers' perceptions of OFS market conditions and potential: At baseline, only two types of improved OFS were available in Kenya—metal silos and hermetically sealed plastic bags (GrainPro and Purdue Improved Crop Storage [PICS] bags, whose distribution was contracted to Bell Industries in late 2013). Across the board, OFS suppliers were very enthusiastic about the potential to supply improved OFS to smallholders, although they also recognized that smallholders' limited awareness and financial/liquidity constraints were impediments to development of market demand for OFS. They perceived these constraints to be particularly relevant to sale of improved OFS for cereals and grains, compared to other, more profitable, crops such as coffee. In consideration of these constraints, OFS suppliers recognized that successful engagement in the market would require investment to raise awareness and subsequent efforts to train farmers on appropriate post-harvest management practices to prepare grain for storage as well as to enable farmers to use the grain correctly. There was also a strong appreciation that smallholder farmers, particularly poor ones, are very price sensitive; hence, keeping costs low would be important to ensure that the improved OFS products would be affordable to as many farmers as possible. Several OFS suppliers provided specific examples of measures they were taking in order to reduce the cost of their OFS products to ensure their affordability to farmers.

With respect to other factors influencing their perception of the market, several OFS suppliers (and potential AgResults implementers) expressed concern that a history of subsidized provision of improved OFS through NGOs and projects could reduce smallholders' perceptions of and willingness to pay for OFS through commercial channels by leading them to expect OFS to be available at a lower cost. There was also some feeling expressed that the playing field was not entirely level, as some potential implementers had at least some of their costs defrayed through NGO, donor, and project funds. Mirroring this, several firms reported that they did not feel that

commercial distribution channels alone could support development of a viable and sustainable market for their product, and they anticipated complementing their commercial activity with donor/NGO/project-supported distribution to achieve a larger volume of sales.

Commercial distributors' perceptions of OFS market conditions and potential: Commercial distributors considered smallholders to offer a strong potential market for improved OFS products, and a large majority of those interviewed (80%) said they would consider carrying one or more improved OFS options if they were given the opportunity to do so by suppliers. Respondents felt that farmer demand would be highest for improved OFS products that were effective in combatting weevils and LGB, familiar and easy to use, durable, and affordable. They also emphasized that the improved OFS products would be particularly attractive to farmers because such products would allow farmers to stop using chemicals, which they noted were not always effective, created concerns about health, and increased farmers' costs. Commercial distributors felt that smallholder farmers offered a strong potential market for sales of improved OFS products. They anticipated sales to farmers of all sizes, both commercial and subsistence, although some commercial distributors perceived that sales could be skewed towards better off farmers, and many emphasized that affordability would be critical for small-scale subsistence farmers. Some respondents also felt that men were more likely to access improved OFS solutions through their outlets, while others felt that women would also evidence significant demand.

When asked about the conditions under which they would enter the market, commercial distributors articulated a need for OFS suppliers to offer an affordable and consistent supply of product, and in many cases advantageous terms such as credit for unsold merchandise that would ease their entry to the market by either reducing costs or risk. They also emphasized the importance of providing solutions that were affordable to farmers with limited resources, and the need for improved OFS suppliers to conduct awareness-raising activities to generate demand for the storage.

Each of the specific improved storage options discussed with distributors was considered attractive because it would control pests without requiring dusting with chemicals. The similarity of pre-treated bags to standard polypropylene bags was considered a major advantage of the former technology, as commercial distributors felt that a familiar option would be attractive to farmers and easy to use. Hermetically sealed bags were noted as being attractive in part because they were a new technology and so would pique farmers' interest relative to polypropylene bags, for which several respondents stated that the market was saturated. Respondents who were interested in the hermetically sealed bins and metal silos considered the availability of a range of sizes to be of particular interest as they could fit the needs of farmers of varying scale. They also expressed confidence that the improved OFS options would be effective against LGB and weevils. Perceived durability was also mentioned in reference to each of the improved OFS options.

Farmer's current and potential demand for improved OFS solutions: Farmers were asked to what degree they considered storage to be a problem or constraint, and what storage issues affected them the most. As summarized in Table 9, nearly two-thirds of farmers interviewed reported storage to be a severe problem for them, and a total of 90% considered storage to be at least a significant constraint. Weevils were reported to be a severe constraint by 61% of respondents, and 49% cited LGB as causing severe problems.

Table 9. Farmers' perceptions of maize storage issues

Issue	Perceptions of maize storage issues				Total Responses	Mean
	Severe (1)	Significant (2)	Minor (3)	Not a problem at all (4)		
Storage as a constraint	64%	26%	6%	4%	72	1.5
Weevils	61%	18%	10%	11%	72	1.7
Rodents	29%	36%	10%	25%	72	2.3
LGB	49%	8%	0%	43%	72	2.4
Aflatoxins	6%	25%	28%	42%	72	3.1
Mould	6%	22%	28%	44%	72	3.1
Theft	1%	17%	14%	68%	72	3.5
Poor post-harvest conditions	31%	18%	14%	38%	72	2.6

In addition to being very aware of storage problems, farmers understand that their current storage practices—use of polypropylene bags with pesticide dusting to kill pests—are not completely effective due to incorrect use of the chemicals as well as problems of counterfeit chemicals and pests becoming resistant to some chemicals. In addition to not being consistently effective, chemicals are also costly, and many farmers have concerns about the potential health effects of feeding chemical-treated maize to their families.

Despite their awareness of the ineffectiveness of current storage practices, most farmers were unaware of the potential to reduce storage losses through use of improved OFS solutions. Both qualitative and quantitative farmer surveys showed that 9 in 10 farmers had never been exposed to improved OFS options, implying very low levels of effective demand for OFS among smallholder farmers at baseline, absent awareness-raising efforts.

When we told farmers about the improved OFS options to understand the potential demand for these options, the farmers evidenced high interest in them. In order to gauge potential demand for these products in qualitative interviews, the interviewer provided an overview of the different generic types of OFS options that were either currently or expected to be available (i.e., metal silos, hermetically sealed plastic bags and bins, and pre-treated polypropylene bags) and described how they worked. Respondents were then asked if they would be interested in using any of the different options, and if so, which. A follow-up question asked what aspects of the option(s) that they chose were most attractive. By far the most prominent trait that farmers valued (and associated with all of the improved OFS options) was the opportunity to have "cleaner" grain because they would not have to treat it with chemicals. The second most important trait, one that they associated in particular with pre-treated polypropylene bags (which are conceptually familiar to them because of their long experience with polypropylene bags) was that they were familiar and would be easy to use. Other traits that farmers valued, in order of declining frequency of mention, included durability, high capacity (particularly with the metal silos), security against rats and theft (again with the metal silos), the ability to store in house, and the ease with which the container (with grain inside) could be moved.

OFS market players' strategies to engage in the OFS market

In this section, we report the results of our inquiries about farmers' and firms' strategies for engaging in the market for improved OFS, focusing on the decision of whether or not to engage in the market at all, and if so how to engage in terms of decisions around product procurement, distribution, and merchandising (as relevant to each market actor). As in the previous section, we address strategies for OFS suppliers, commercial distributors, and farmers. We focus first on their current strategies and then on projections about their strategies once the pilot officially begins, although the projected activities receive the brunt of attention given the lack of current awareness and activity for farmers and commercial distributors at baseline.

Prior to the baseline assessment, we hypothesized that potential OFS suppliers refrain from making large-scale entry into the market due to a perceived lack of demand, with much of the private sector engagement in the market that exists focused on low-risk approaches. These approaches include sales through large organizations such as NGOs and donor-funded projects, which then took responsibility for distributing the storage solutions to farmers on a subsidized basis. Likewise, commercial distributors were hypothesized to have little involvement in the market and to take a low-risk approach to market entry if they engaged at all. We hypothesized that the farmers stored their maize using traditional and familiar methods, in large part due to their lack of awareness of the existence of alternative storage solutions. We also hypothesized that farmers sell their maize soon after harvest to meet their need for cash as well as to mitigate anticipated storage losses, and that they purchase maize to meet their families' consumption needs if and when their household stores run out.

These hypotheses were largely borne out, although an unexpected result was the strong expected willingness of all value chain players to engage in the market once they were exposed to the existence of improved OFS products and their potential market. This willingness assumed that appropriate conditions could be put in place to facilitate entry into and success in the market.

OFS supplier strategy: As noted above, only two types of improved OFS were available in Kenya at baseline—metal silos and hermetically sealed plastic bags. Metal silos were introduced by CIMMYT, and the Effective Grain Storage for Sustainable Livelihoods of African Farmers project trained local artisans to manufacture metal silos. From a marketing standpoint, the CIMMYT-affiliated National Association of Metal Silo Manufacturers works under contract with different entities (such as NGOs and Ministry of Agriculture offices) to train local artisans in their manufacture. These artisans then work to fulfil orders for the silos, often selling them through bulk orders made by NGOs or charities, which then distribute the silos on a subsidized basis to farmers (one artisan interviewed stated that only 20% of the farmers who purchase his silos pay full price). Metal silos are provided with an array of associated services including delivery and installation of the silo, and training on its proper use and maintenance (provision of these services can be the role of the coordinating agency or the silo manufacturer).

Baseline results showed hermetically sealed bags being distributed to farmers through three major channels:

- Through agencies and organizations that buy bags and facilitate their distribution (often on a subsidized basis as part of a social mandate)

- Through direct marketing of bags to farmers, where supplier salespeople interact directly with farmers at public events, such as trade fairs and field days, and sell bags for cash on the spot
- Through subsidized sales via agro-input dealers on a cash or consignment basis, these sales often being subsidized through NGOs or development projects.

In all cases, bags are delivered with basic information on their proper use and maintenance, often in the form of visual aids accompanied by verbal instructions. These distribution strategies, and variations on them, are likely to be carried over to AgResults activity, with adaptation to reflect the parameters set by AgResults and OFS suppliers' own perceptions of what it will take to establish a sustainable market presence.

Potential and current OFS suppliers (all of which were potential AgResults implementers) were still in the process of determining important aspects of their rollout plans at the time of the interviews; and in some cases where new OFS products were being developed, the products themselves were not yet finalized. That said, preliminary responses and application information reflect a large diversity of intended products, procurement, and merchandising strategies on the part of implementers.

A variety of improved OFS products were projected for rollout, including hermetically sealed plastic bags, hermetically sealed plastic bins and tubs, pre-treated/pesticide-impregnated plastic/polypropylene bags, and metal silos. Most suppliers intended to offer several sizes and different product options, with these options reflecting variations on a basic design to achieve product options that varied in their durability and cost, and in the types of storage problems that they would protect against. Overall, planned product offerings varied widely in terms of their storage capacity, ranging from 25 kg for some bags to 540 kg, which is the maximum capacity permitted by the pilot.

Most potential AgResults implementers expressed their intent to participate simultaneously in both versions of the pilot incentive (the one for the Rift Valley region and the one for the Eastern region), and designed their product portfolios to respond to the different technical requirements of the different incentive structures. For example, one OFS supplier intended to offer a two-ply bag that would be useful for most storage needs, as well as an extra-sturdy three-ply bag that would be effective against LGB, which is a problem only in some locations. In some cases, ongoing development or certification implied that there would be a lag before the LGB-proof solution was introduced to the market. This was complemented by the shift in the Rift Valley incentive structure to reward the first five (rather than all) implementers to reach the first sales milestone, which also led some firms to announce that they were focusing their early market entry on the Rift Valley. Apart from these timing strategies and the expectation that LGB-proof storage solutions would be offered exclusively in the Eastern counties and both LGB-proof and non-LGB-proof products would be offered in Rift Valley counties, implementers did not differentiate their sales or promotion strategies on the basis of the incentive structure or region.

Suppliers' procurement strategies for OFS products differed widely on the basis of the particular type of OFS product as well as whether the firm was already engaged in the market. Some products, such as metal silos, were to be constructed by local artisans; while others would be imported either from the firm's own manufacturing plants or a contracted manufacturer. Several implementers reported that, although they intended to begin by importing their OFS products,

they were also investigating or initiating domestic sourcing in order to have more control over production processes as well as avoid customs fees on their imports. Likewise, implementers were split in their reliance on their own manufacturing capabilities versus outsourcing, but several that were currently outsourcing stated that they would consider investing in their own production facilities if the initiative showed adequate promise.

Firms anticipated marketing through major two major channels—direct sales through farmers' organizations and sales through commercial distributors of agro-inputs and farm implements. One additional firm that applied to participate in the pilot had a unique approach that incorporated sales of improved OFS into a vertically coordinated and demand-driven cereals value chain initiative. This firm's intent was to develop an integrated system leveraging a major micro-finance initiative, agro-dealer networks, privately contracted and government extension workers, and agro-input companies. Together, this network would provide farmers with a quality-guaranteed input bundle (including the implementer's improved OFS products) and guaranteed product buy-back of their cereals. This "outlier firm" was, it is important to note, making the most of the AgResults pilot as an opportunity to work improved OFS sales into an established system rather than building the system around the OFS pilot.

Sales through farmer organizations were often intended to leverage the associations' capacity to serve as a facilitator of bulk purchases to provide credit for the sales and farmer training. One benefit offered by these organizations was the possibility of immediate payment to the OFS supplier, with the organization serving as a financier of the farmers' purchases, possibly even receiving payment in kind if it also played a role marketing farmers' produce. Sales through commercial distributors of agro-inputs and farm implements offered the opportunity for some OFS suppliers to leverage existing distribution arrangements; though there was widespread agreement that commercial distributors would be extremely limited in terms of their ability to provide services such as training and education to the farmers to help them to most effectively use the products.

Several suppliers also planned to partner with other firms or non-profit organizations (such as NGOs or the extension service) for OFS product distribution, promotion, and/or training.

Suppliers that anticipated marketing through commercial channels expressed awareness that commercial distributors would have an interest in reducing their risk exposure as they entered a new market segment, but were cautious about operating on consignment given the adverse incentives that this could introduce (such adverse incentives ranged from a lack of motivation to market the product to concern that inventory would disappear). An exception to this was those suppliers that had extensive experience (or even formal relationships) with specific distributors, in which case it was perceived that trust or other safeguards were in place to protect them from these risks. In general, while OFS suppliers generally preferred to work with commercial distributors on a cash basis, they recognized that in some specific cases consignment sales could or would be arranged.

Anticipated pricing, promotional approaches, sales volumes, and service provision (such as training, product warranties, and product delivery) also varied widely across OFS types and individual OFS suppliers. Several respondents emphasized the need to offer their product at a competitive price. In general, however, it seemed apparent that different OFS suppliers were developing their merchandising approaches without significant awareness of the strategies of

competing firms, and while they were concerned with things like having competitive prices they did not necessarily have specific price points that they were competing against. Given the apparent lack of awareness of different OFS suppliers' strategies, it is likely that there will be rapid adjustments to or evolution of these strategies once several firms are directly competing in the market.

Three major factors influenced potential implementers' geographic focus for their upcoming merchandising activities:

- Firms will seek to work through existing supply channels or where they already have some sort of established presence.
- Firms anticipate selling where they feel there is the most significant potential demand—perceptions of where demand will be highest tend to differ on the basis of whether firms perceive themselves to be selling to more commercially or subsistence-oriented farmers.
- Several firms expressed that the pilot incentive structure makes it more beneficial to focus sales on Rift Valley over Eastern counties, as they anticipated that this focus would offer a higher and earlier reward for their efforts.

Several firms reported that they intend to market throughout the entire pilot area, but others expressed that they do not have the resources (particularly operating capital) that would be required for a broad rollout and thus intend to focus their activities in specific areas at the outset. There was no indication that firms that intend to participate in the pilot in both regions are tailoring their marketing and distribution systems to the differential pilot incentive structures or to the different regions where they will be selling.

Commercial distributors' strategy: At baseline, commercial distributors evidenced very limited involvement in the market for OFS (even traditional), and even less involvement in the market for improved OFS solutions. One-third of commercial distributors interviewed sold polypropylene storage bags, and several (9%) sold sisal, while two respondents (6%) sold hermetically sealed bags, in both cases sourced from Bell Industries. Volumes sold annually for each type ranged broadly—between 50 and 5,000 for the polypropylene bags and between 100 and 1000 for the hermetically sealed bags. Polypropylene bags sold for an average of KES 36 each, while the hermetically sealed plastic bags were reportedly priced at KES 400[11]. Firms selling the hermetically sealed bags reported that they included information (e.g., a brochure) and training on how to use them to the buyers. Buyers of the hermetically sealed bags were described as including both large and small-scale farmers, with more purchases by commercial farmers. While both men and women were reported as buying the polypropylene bags, one of the distributors of the Bell bags reported that they were mainly sold to men—this was in a more commercially-oriented production area where men are heavily involved in cereal production for the market.

With the exception of the few distributors that carried hermetically sealed bags, most agro-input dealers were either completely unengaged in the market for OFS or sold only the default standard, polypropylene bags. Eighty percent of the commercial distributors interviewed

[11] This is a significantly higher price than the price at which OFS suppliers market the bag. In addition to reflecting the commercial distributors' margin, this price may also reflect that the bag has passed through more than one level of intermediation, with a margin being added at each transfer.

expressed that they would be interested in stocking improved OFS products that they perceived had good market potential if given the opportunity to do so. Specifically, 50% said they would consider carrying hermetically sealed bags, and 44% expressed interest in pre-treated bags. There was less interest in hermetically sealed bins or tubs (4%) and metal silos (6%). These results are not surprising given that hermetically sealed plastic bins are not yet out in the market so there is little familiarity; also, both metal silos and plastic bins are bulky items that cost more and require more space to be stocked.

When asked what interactions and relationship traits would most likely facilitate their entry to the market for different OFS options, the following perceptions emerged from distributors:

- OFS suppliers should approach them, and ensure a consistent supply with delivery to the distributor.
- At the outset, there should be advantageous terms (such as credit or instalment payments) to help distributors overcome the risk and cost of carrying the bags.
- Suppliers should undertake marketing and awareness-raising activities to ensure demand.
- Affordability to farmers and profitability/fair pricing to the distributor would be key to successful establishment of commercial distributors as a distribution channel.

Farmer strategy: At baseline, farmers almost exclusively relied on traditional methods of storing their grains; in particular, use of polypropylene bags with a pesticide dusting. While they recognized storage losses to be a significant problem, they were unaware of any alternatives to the long-standing methods that were in use, such as improved OFS products. As such, given the extremely low levels of awareness of improved OFS and uptake in the market, it is difficult to meaningfully discuss current farmer strategy for engagement in the market, as "strategy" implies a deliberate decision making process that utilizes relevant information. Discussion in this section thus focuses on farmers' reflections on whether and how they would engage in the market once they were exposed to the improved OFS.

As discussed in the previous section, farmers were keenly interested in improved OFS products once they were apprised of their existence and given a basic overview of the different options that were currently or likely to become available. They were particularly interested in OFS products that were similar to products they were already familiar with (such as pre-treated polypropylene bags) and that they felt would be easy to use, and they valued durability.

When asked how they would use the OFS, all farmers that they would store maize (their most important food crop) in it, and some also expressed an interest in using the OFS to store beans. They valued being able to use the improved storage to store grain for longer with less loss, both for their own families' use and so that they could sell it at some point after harvest when prices improved.

An important point about many of the improved OFS options is that they are useful only for storing grain, and not for transporting it. Clearly, for example, metal silos are not intended for transport of grain, but even smaller OFS options such as hermetically sealed bags are vulnerable to damage if used to transport grain rather than simply to store it. This implies that, even in the face of the successful development of a market for OFS, standard polypropylene bags (or improved OFS products that are improved bags) will still maintain a role in farming systems. They are likely to be used to transport maize from the field to the location where it will be dried, and then where it will be stored, as well as to move it to market once it is offered for sale. In

contrast, the improved storage options are designed to be used exclusively for storage of maize and grains, reflecting their greater value, specialized functionality (particularly larger products such as metal silos and plastic bins), and greater vulnerability to damage (such as the hermetically sealed plastic bags).

Farmers' great interest in using the improved OFS primarily to store food for their families, the expectation that they will use the products only for storage (not for transport), their unfamiliarity with the products, and their limited financial means all imply that they will enter the market for improved OFS slowly and conservatively. Farmers' statements about how they would purchase products such as pre-treated or hermetically sealed bags supported this expectation. Farmers said they would ideally start by purchasing just one item to experiment with and familiarize themselves with it, and then purchase more units in subsequent seasons as money became available and they became convinced of the devices' utility. This suggests that smaller-unit OFS options, such as bags, might have an advantage in the market, as farmers can purchase them without substantial commitment or investment. It also suggests that even when farmers have purchased one storage solution they will not necessarily be locked into that solution—if another option became available that seemed to have better features or a more attractive price, then farmers could diversify their purchases over time to gain greater exposure or otherwise experiment until they found the product that they liked best.

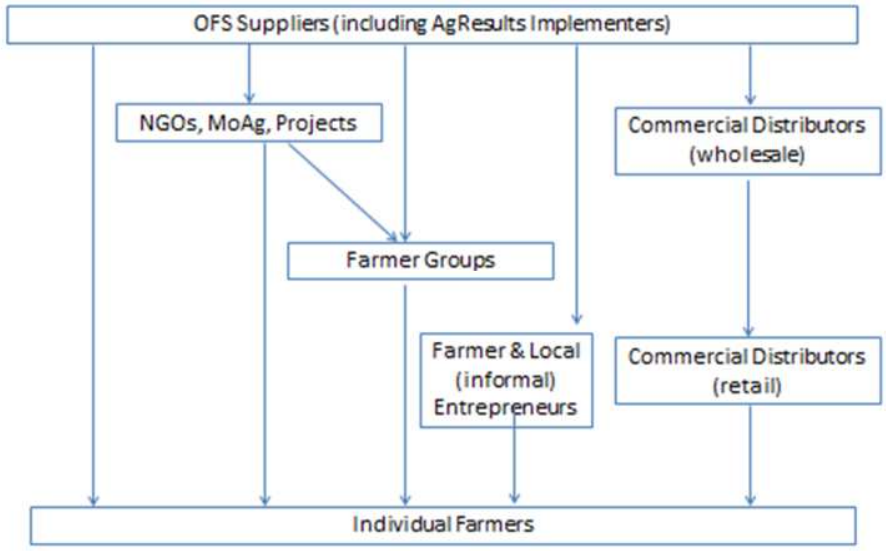
Corresponding to their incipient awareness, farmer respondents generally were unaware of where they could or would purchase improved OFS products, though they were open to different sources and amenable to the possibility of purchasing the products from commercial distributors such as agro-input dealers. When asked how they would finance the purchase, most farmers stated that they would draw on household savings; only one respondent stated outright that she doubted she would be able to afford it.

Market structure for OFS

This section characterizes the structure of the existing and potential market for improved OFS, focusing on the marketing channels along which OFS products flow and the agents involved and transaction points along those market channels. Prior to the baseline assessment, it was hypothesized that the market for improved OFS was dominated by non-profit organizations that procure improved OFS and distribute it to farmers. Commercial market flows (moving from profit-oriented OFS suppliers to commercial distributors to farmers), on the other hand, were hypothesized to be minimal. These hypotheses were supported by the baseline assessment.

Currently, the market for improved OFS is incipient, and nearly all farmers rely on polypropylene bags that they obtain from market centres or some commercial distributors. At the time that baseline data were collected, there were only two different types of improved OFS products available in the Kenya market—artisan-produced metal silos and hermetically sealed plastic bags (either GrainPro or PICS). The market for improved OFS at that point had three primary distribution channels— distribution to farmers through non-profit entities, direct sales by suppliers to farmers, and sales through commercial distributors (see Figure 8).

Figure 8. Current market structure for improved OFS



The most important market channel, in terms of volume of sales[12], relies on non-profit entities to coordinate and facilitate purchase and distribution of improved OFS to farmers. Such non-profit entities include donor-funded projects (e.g., USAID-funded KAVES), NGOs (such as Caritas), or the government (through county extension or national initiatives). It is important to note that while this channel does constitute a market in that the OFS suppliers are selling the storage on a commercial basis, the non-profit entities most often re-distribute the OFS products on a subsidized basis or free of charge, and sales through such channels are disallowed from the AgResults competition. A variation on this channel is sales in which farmer organizations serve as intermediating agents, with the organization serving as a point of aggregation, training, and promotion and possibly a source of in-kind credit.

Direct sales to farmers are undertaken by OFS suppliers using public forums such as agricultural fairs, farmer field days, and market days to educate the farmer and to promote the OFS product. This market channel is cash-based and was responsible for a relatively small share of sales of improved OFS compared to the above-described non-profit channels at the time of baseline data collection.

The third major distribution channel, sales through commercial distributors, involves several possible "sub-channels" and at times, multiple layers of transactions among formal and informal distributors. For example, some OFS suppliers market through large, wholesale agro-input distributors on either a cash or consignment basis. These large distributors in turn market the OFS products through their outlets, which typically sell directly to farmers as well as to local "stockists" (retailers) or even local farmers or extension agents who buy on a cash basis and sell

[12] Data are forthcoming about the specific volume of commercial flows through different market channels.

directly to farmers. These sales can involve multiple stages of buying and re-selling with corresponding price increases at each stage. Alternatively, some OFS suppliers sell directly to the aforementioned stockists and entrepreneurs, working on a cash basis, with them re-selling to farmers as already described.

OFS market performance

At baseline, the market for improved OFS was a characteristic "missing market" in that latent demand exists for a valuable product without corresponding commercial availability to meet that demand. This missing market exists despite indications that the size of demand for the product would be enough to sustain substantial commercial activity. In its "missing" state, this market cannot be judged to be failing any specific socio-economic or other vulnerable groups in particular, as it has failed to emerge as a whole to date.

Smallholder farmers are a diverse group, with significant variation in scale, orientation of production (commercial or subsistence), reliance on agriculture for their livelihoods and access to non-agricultural sources of income, location, and socio-economic status including gender. OFS suppliers' distribution strategies (with their focus on agricultural organizations and commercial distributors) suggest that improved OFS products are most likely to reach farmers who are relatively better off, as these are often the farmers who frequent commercial agro-input distributors or participate in farmer organizations, and are most likely to be able to be exposed to and able to afford improved OFS.

These distribution channels represent more than a convenient means to reach smallholder farmers—they are also a direct route to the farmers for which OFS suppliers perceive the most dynamic market potential to exist. More commercially oriented farmers represent "low-hanging fruit" from a market entry and sales standpoint, and it is a reflection of their underlying business orientation that the suppliers will target them first.

Suppliers' tendency to focus their investments on the best-off smallholders has two implications for the pilot's potential impact on the development of markets for improved OFS. First, it implies that, even if successful in establishing commercial markets for OFS, the pilot could still see less impact on uptake by the poorest, most isolated, and socially disadvantaged (for example female-headed households), even in those areas where improved OFS becomes commercially available and better-off farmers are buying into the market. In this case, the pilot would resolve the availability issue, even if it would not effectively stimulate demand among particularly disadvantaged farmers.

Second, the high-end focus of suppliers and distributors implies that private sector investment in the improved OFS market could be particularly weak in geographic areas with high concentrations of poor farmers. These areas may remain underserved in terms of OFS suppliers' investment in distribution networks in those areas and/or the engagement of commercial distributors in the market. In these areas, neither supply-side nor demand-side constraints to increasing OFS uptake among smallholders will have been effectively addressed.

Gender-differentiated performance: Consistent with these observations, there is particular potential for the pilot to have differential impacts across different social groups, including by gender. As described earlier, female-headed households tend to be less literate, with fewer economic resources, and a greater tendency towards a subsistence orientation in production. As

discussed, these households are less likely to have access to improved OFS through the commercial market channels that are likely to be catalysed by the pilot.

Generally, these results imply that the pilot for OFS may have a lesser impact on female-headed households than it does on male-headed households, because of the likelihood that female-headed households will find it more financially prohibitive to purchase the improved OFS than the relatively better-off male-headed households, Female-headed households may also be in a poorer position to be exposed to and learn to use improved OFS thanks to their lower levels of education and relative geographic isolation, which can reduce their exposure to, uptake of, and ability to use improved OFS.

Synthesis and implications of results

Results of the SCP analysis indicate that the baseline situation is largely as was represented in the business plan and are also consistent with the hypotheses that were presented for testing in the evaluation design. Likewise, the AgResults pilot appears to be poised to stimulate the entry of multiple OFS suppliers into the heavily underserved market for improved OFS solutions. There are indications that a commercial supply of improved OFS will be established throughout much if not all of the pilot area; the possible exception being in the poorest areas, where a concentration of poor and highly price-sensitive farmers might be overlooked in favour of market development activities in areas with a greater base of buyers with ready purchasing power.

With respect to perceptions of the basic market conditions that influence firms' investments in the market, in general there is a high degree of awareness among value chain actors (particularly OFS suppliers and commercial distributors) about farmers' storage issues, needs, and preferences. For example, there was significant commonality among commercial distributor and farmer responses about affordability as well as preferences towards OFS options that would be familiar to them and relatively easy to use. Likewise, there was broad consensus that smallholder farmers could potentially represent a dynamic and attractive market, although that market would need development through awareness creation.

Based on firms' and farmers' perceptions of the product and its market, which imply the potential for a sustainable market to emerge, there are preliminary indications that AgResults may be able to catalyse investment into the market at a scale and with an underlying diversity of approaches that will create the conditions for dynamic and sustained market development. Nonetheless, there was some divergence between OFS supplier and commercial distributors' expectations about what it would take to enlist commercial distributors as outlets for OFS products. In particular, commercial distributors' preferences for arrangements that would limit their risk exposure, possibly through consignment operations, and OFS suppliers' aversion to consignment sales as a standard approach. That said, OFS suppliers generally did not categorically rule out consignment sales; rather, they expressed that consignment sales were risky and were best undertaken with a distributor with whom they were familiar and had a trusting relationship.

While the business plan was developed with an expectation that OFS suppliers would work with commercial distributors as outlets for their OFS products, it was hypothesized that they would also develop alternative outlets such as farmer organizations, leveraging their unique access to farmers and social capital to overcome some of the financial and awareness issues that would

otherwise inhibit demand. Baseline findings supported the hypothesis that both commercial outlets and farmer organizations would serve as outlets, though suppliers evidenced an additional degree of innovation in their tendency to also leverage non-profit charitable, donor, and government organizations to help develop demand and train farmers on the OFS products that they were marketing. In short, OFS suppliers' anticipated distribution strategies typically reflect both diversification and innovation, and make good use of non-profit resources and mandates; while still staying within the parameters of the pilot incentive structure by ensuring that the development of a commercial market would not be compromised through subsidized sales. It is also likely that the non-profit organizations engaged as partners in the pilot will provide important linkages to specific groups, such as women and the poorest smallholders, who otherwise would be underserved.

Finally, it will be important throughout the course of pilot implementation to explore the differential factors affecting the exposure to, access to, and uptake of improved OFS among different social groups, as exemplified by the previously noted differences between the two implementation regions, female-headed and male-headed households.

4.2 Evaluation Question 2: What has been AgResults' impact on smallholders' uptake of on-farm storage technologies?

In this section, we present the baseline conditions of smallholders' uptake of improved OFS. In addition to examining the uptake of OFS, we also assess awareness about OFS technologies, and knowledge, awareness, and practices about other post-harvest storage practices that affect the efficacy of the OFS technologies.

As discussed above, we have conducted a regression analysis to determine the time trend in the use of OFS prior to implementation of the pilot, controlling for observable characteristics at the smallholder farmer level. This analysis uses data collected in 2014 by the large-scale survey of famers described earlier, with recall information to create data points about use of OFS in 2013, 2012, and 2011. As discussed above, to leverage the opportunity provided by the delayed implementation of the project, we will update this time trend with additional baseline data gathered in 2015 on OFS uptake in 2014. This analysis will determine the trends in OFS uptake prior to the formal implementation of the on-farm storage technology interventions from which we will later project the "counterfactual" trend as a benchmark for measuring the impact of the pilot on smallholders in 2015 and beyond.

For all other outcomes—awareness of OFS, knowledge and practice of other storage practices—we present the current prevalence measured in mid- to late 2014 for the 2013 harvest. Our analysis of impacts on these factors will use a before and after analysis once the endline data are collected. Below, we first present the current storage and post-harvest practices, followed by awareness and uptake of OFS and gender-differentiated results.

Baseline trend in OFS technology adoption: Using three data points on uptake of OFS in 2011, 2012, and 2013, we estimated a baseline trend prior to the implementation of the pilot intervention, which we will later project out in time to use as the counterfactual for the smallholder impact analysis.

Using the regression model in Equation 1 (described in Section 3.2 and reproduced here for ease of reference), we ran the analysis separately for the Eastern and Rift Valley regions, in order to

allow for potentially different trends under the two sets of circumstances[13]. In each region, counties were selected purposively for the sample based on growth of maize and likelihood of being targeted by implementers. Within each county, villages were sampled randomly, and within each village, households were selected randomly for the survey administration. Therefore, in each region, the nesting structure in the data will be of the following form: individual observations (or time) nested within households nested within villages nested within counties.

(1) $Y_{thjk} = \beta_0 + \beta_1 time_t + \sum_{n=1}^{N} \beta_{n+1} X_{thjk}^{n} + \sum_{m=1}^{M} \beta_{N+1+m} W_{tjk}^{m} + \sum_{r=1}^{R-1} \beta_{N+M+1+r} C_k^r + \mu_{jk} + \delta_{hjk} + \epsilon_{thjk}$

where:

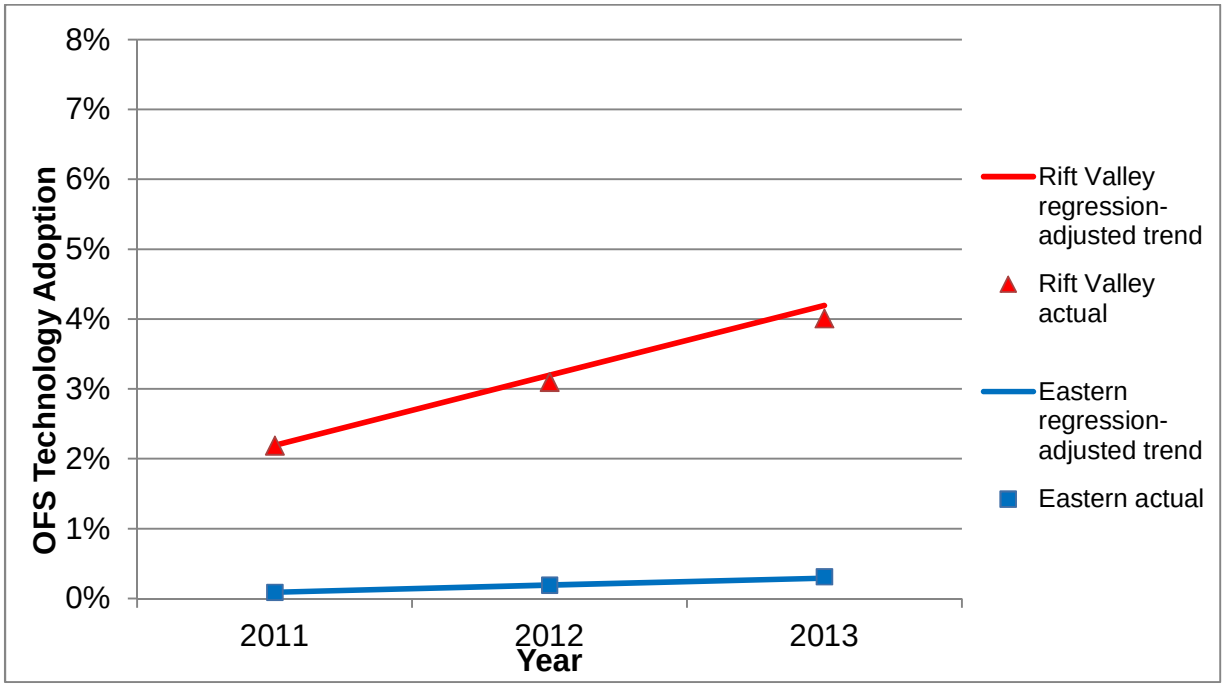
Y_{thjk} = Dummy =1 if household *h* in village *j* in county *k* at time *t*, adopted any of the improved OFS technologies. The other variables are as described in Section 3.2 above.

Our results indicate that very few households in either region have adopted improved OFS technologies in the period 2011 to 2013, but with a relatively higher adoption and increasing trend in adoption of improved OFS in Rift Valley, driven largely by adoption of metal silos and PICS bags (see detailed regression results in Appendix H). The regression-adjusted time trend suggests that over time the adoption of OFS has remained mostly flat in the Eastern region, while the trend is increasing in Rift Valley. In the Eastern region, we observe a 0.1 percentage point increase in the average use of OFS over three years, as compared to a 1 percentage point increase over time in the Rift Valley[14]. Both estimates are statistically significant at the 1% level. As depicted in Figure 9, in the Eastern region only 0.1% of households adopted improved OFS in 2011, which grew to 0.3% in 2013. In the Rift Valley region, 2% of the households reported adopting OFS in 2011, which increased to 4% in 2014. These relatively low adoption rates are expected given that only a few of these technologies, such as PICS bags and metal silos, were available in those years. The relatively larger increase in adoption prior to the pilot in the Rift Valley region also reflects the AgResults pilot expectation that pilot efforts will increase adoption rates much more in the Rift Valley region. The pilot expects to increase adoption rates to 18% in the Rift Valley region and 6% in the Eastern region.

[13] While this model could be modified to include non-linear time trends, we do not take this step given that the OFS uptake outcome is visibly stable over the pre-implementation time period.

[14] Both estimates were statistically significant at the 1 percent level.

Figure 9. OFS adoption trend lines for the Eastern and Rift Valley regions, fitted by regressing yearly figures reported by the baseline survey



Disaggregation by Gender and Poverty: We conducted analysis separately for vulnerable groups, notably female-headed households and households classified as poor. The disaggregation by region, gender, and poverty status reveals that there is also very little difference across the subgroups in measured trends in the adoption outcome over time. These results set the stage for a fairly transparent analysis of post-implementation impacts of the pilot as the shift in the linear trend's endpoint—measuring the change in impact over time after implementation.

Awareness and adoption of OFS: In order to better understand the low baseline adoption rate, we also examined smallholder awareness of the different technologies and the adoption of technologies by type of technologies when interviewed in 2014 (we did not ask about awareness in preceding years). Again, not surprisingly, awareness was extremely low prior to the pilot. As shown in Table 10, only about 10% of respondents in the Eastern region and 12% in Rift Valley said they were aware of at least one improved OFS option when interviewed in 2014. Metal silos, which have existed for many years and have been promoted in Kenya by various NGOs, registered the highest overall awareness with 4.4% in Eastern and 4% in Rift Valley (although as we discuss later, their adoption was very low). PICS bags, which have begun to be marketed heavily in some areas over the past few years, were known by 3.1% of Eastern respondents. Awareness was much higher in Rift Valley, where 7.5% of respondents were aware of PICS bags. Less than 2% of farmers indicated awareness of any of the other technologies listed in Table 10. In all cases, female-headed households were less likely to report awareness of the improved OFS technologies than male-headed households. Since most of these technologies are not yet available on the Kenyan market, it is surprising to see any positive awareness of storage solutions like the Vestergaard ZeroFly bag. It is possible that some farmers have exaggerated their knowledge of the technology to appear knowledgeable to the interviewer or simply are mistaken in what technology they meant to report.

Table 10. Percentage of baseline survey respondents who were aware of improved OFS technologies

OFS technology	Eastern			Rift Valley		
	Total	Male HH head	Female HH head	Total	Male HH head	Female HH head
Hermetically sealed bags						
PICS	3.1%	3.3%	2.6%	7.5%	7.5%	7.6%
GrainPro SuperGrainBag	0.5%	0.6%	0.4%	0.2%	0.2%	0.0%
KPMC	0.2%	0.3%	0.1%	0.4%	0.2%	1.1%
Pre-treated bags						
AtoZ AgroBag	1.3%	1.4%	1.2%	0.4%	0.2%	1.1%
AtoZ AgroBag Plus	0.5%	0.6%	0.4%	0.0%	0.0%	0.0%
Vestergaard ZeroFly bag	0.2%	0.3%	0.0%	0.2%	0.0%	1.1%
Hermetically sealed plastic bins/tubs						
Kentainers	1.6%	1.5%	1.9%	0.2%	0.2%	0.0%
Metal Silo						
Metal silo	4.4%	4.8%	3.1%	4.0%	4.8%	0.0%
All OFS technologies combined	**10.0%**	**10.5%**	**8.4%**	**12.0%**	**12.5%**	**9.8%**

Note: reported awareness statistics here refer to awareness on the date the interview was conducted (i.e., in July or August 2014).

In terms of adoption, only 0.3% of the households in the Eastern region and 4% of the households in the Rift Valley region report ever having purchased any of the improved OFS technologies that AgResults may promote. PICS bags account for almost all of this pre-pilot adoption (see Table 11). In both regions, PICS bags were the most commonly adopted technology, with 0.3% adopting in the Eastern region and 4% adopting in Rift Valley. Adoption rates for all other technologies AgResults may promote are negligible. This is surprising for metal silos and GrainPro bags, which have already been introduced in the regions.

Table 11. Percentage of baseline survey respondents who report ever having purchased improved OFS technologies

OFS technology	Eastern			Rift Valley		
	Total	Male HH head	Female HH head	Total	Male HH head	Female HH head
Hermetically sealed bags						
PICS	0.3%	0.4%	0.1%	4.0%	3.7%	5.4%
GrainPro SuperGrainBag	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
KPMC	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Other	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%

Pre-treated bags						
AtoZ AgroBag	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
AtoZ AgroBag Plus	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Vestergaard ZeroFly bag	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Hermetically sealed plastic bins/tubs						
Kentainers	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Metal Silo						
Metal silo	0.0%	0.0%	0.1%	0.2%	0.2%	0.0%
All OFS technologies combined	**0.3%**	**0.4%**	**0.1%**	**4.0%**	**3.7%**	**5.4%**

Other post-harvest practices: Next, we discuss the current post-harvest practices of the households when interviewed in 2014 to better understand the extent to which behaviour change will be needed to fully benefit from the improved OFS. Grain must be clean, dry, and (in the case of hermetic bags) stored on a raised platform away from walls for farmers to reap the full benefits of improved OFS technologies. If farmers fail to create these conditions, the pilot may not have its full intended effect. Therefore, for the pilot to have sustainable impact on the adoption of OFS, it will have to generate broader awareness about post-harvest handling practices. Accordingly, we designed the survey to capture the extent to which farmers are aware of and employ various post-harvest practices, which we will compare before and after the intervention. Specifically, the survey asked farmers a series of questions about their post-harvest grain handling practices, eliciting information both on what farmers consider "best" handling practices (their awareness) and on what they actually do (their practice). As Table 12 shows, there is general agreement between what farmers believe is a "best" practice and what practice they use themselves. Accordingly, we do not discuss differences in best versus actual practices except where there are large discrepancies[15].

The results suggest that there are gaps in the knowledge about what is a good practice. Drying grains is perhaps the most important step in successful adoption of OFS, and the results suggest that farmers are aware of this (almost all farmers report drying their grain and testing for moisture); however they do not have knowledge about (and potentially access to) improved methods to dry their grain or do not know that they are best practices. For example, most farmers in the Eastern region (more than 80%) say they dry cobs on the ground and believe that to be a best practice; the same is true for just over half of Rift Valley farmers. This is not a recommended practice and can lead to poor drying and contamination by fungus. Only about a quarter of Rift Valley farmers prefer drying on tarpaulins—which is an improved practice—while around a tenth of Eastern farmers say they do. Placing grain in cribs for further drying is popular in the Rift Valley (about 45% do this and say it is a best practice, while only 12.5% in the Eastern region talked about cribs). Notably, very few farmers (less than 3%) in either region say that they cover grains at night or know that to be a best practice.

[15] There was also general agreement in the post-harvest patterns of female- and male-headed households; hence, for simplicity this section discusses practices for male and female household heads combined.

For moisture testing, nearly 75% of farmers in the Eastern region prefer using the sound the grain makes to gauge if it is dry enough; just over a third also mention biting kernels to test for dryness. In Rift Valley, the proportions were nearly opposite: about 43% say they listen to the sound the grain makes, while about three-quarters prefer to measure dryness by biting the kernels. Very few farmers (2.4% or less) mention other methods as a best practice or as their actual practice, with one exception: 7.9% in Rift Valley say that using a moisture meter is a best practice, though only 0.2% report actually using a moisture meter themselves. There were also a number of Eastern farmers (4.8%) who say they do not know the best practice for testing moisture, though only 0.4% of farmers in Rift Valley say the same.

Although not as critical as drying, proper shelling is important to ensure the efficacy of improved OFS. Shelling by beating can cause grain damage, leading to greater exposure to insects and fungus. Most farmers (around 70%) in the Eastern region report that shelling by beating is the best shelling practice and the one they use. About 45% prefer shelling by hand in the Eastern region. In Rift Valley, respondents are more split: 54.7% say shelling by beating is the best practice, and 50.4% say that is what they do; 49.9% say machine shelling is the best practice, and 39.5% say that is what they do; and 26.3% say that hand-shelling is the best practice, with 23.4% saying they practice hand shelling.

Finally, most farmers say they bag shelled grain for storage—a recommended practice—and consider it a best practice (about two-thirds in the Eastern region say this, and 83.2% of farmers in Rift Valley say it is a best practice, while 91% say it is what they did in 2013). Only a little more than a third of farmers mention the practice of storing grain on raised platforms away from walls, which is also important for ensuring that certain improved OFS solution (e.g., hermetic bags) are effective.

Table 12. Percentage of baseline survey respondents reporting each post-harvest handling practice

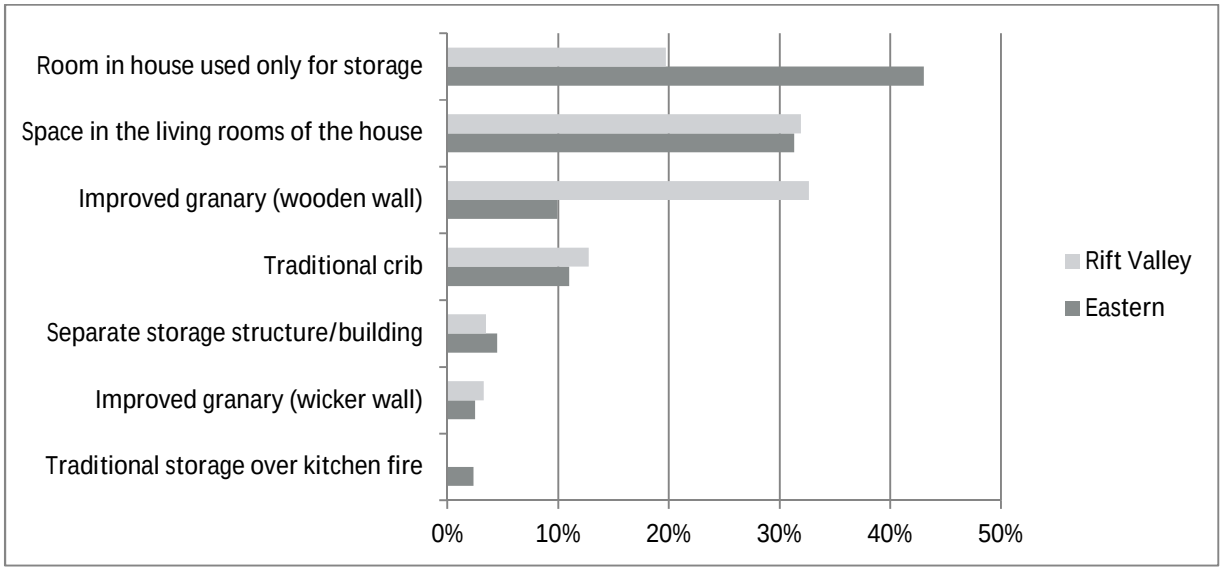
Drying				
	Reported "best" practice		**Actual practice***	
	Eastern	**Rift Valley**	**Eastern**	**Rift Valley**
Covering at night	2.9%	0.6%	2.3%	1.1%
Drying on tarpaulins	11.4%	25.0%	9.5%	24.2%
Crib for further drying	12.5%	44.4%	12.5%	46.1%
Drying cobs on ground	84.2%	54.9%	81.0%	52.1%
Don't know	0.7%	0.4%	4.8%	1.5%
Testing moisture				
	Reported "best" practice		**Actual practice***	
	Eastern	**Rift Valley**	**Eastern**	**Rift Valley**
Moisture meter	1.0%	7.9%	0.8%	0.2%
Glass bottle with salt	2.4%	0.0%	1.8%	1.1%
Bite kernels	34.5%	74.0%	33.3%	78.6%
Listen to sound the grain makes	74.7%	43.0%	71.3%	43.0%

Don't know	4.8%	0.4%	8.5%	1.7%
Shelling				
	Reported "best" practice		**Actual practice***	
	Eastern	**Rift Valley**	**Eastern**	**Rift Valley**
Shell immediately when dry	3.6%	1.1%	3.0%	1.1%
Shell by machine	6.5%	49.9%	4.5%	39.5%
Shell by hand	45.8%	26.3%	44.5%	23.4%
Shell by beating	71.7%	54.7%	69.7%	50.4%
Don't know	0.4%	0.2%	4.4%	2.1%
Storing				
	Reported "best" practice		**Actual practice***	
	Eastern	**Rift Valley**	**Eastern**	**Rift Valley**
Bulk (no bagging)	3.3%	5.3%	3.8%	3.0%
Raised platform/away from walls	39.0%	46.3%	36.3%	35.8%
Bagging of shelled grain	66.8%	83.2%	64.0%	91.0%
Don't know	0.8%	0.5%	5.0%	2.6%

Notes: Figures may sum to more than 100% because practices in each category are not mutually exclusive.
Because of general agreement in the post-harvest patterns of female- and male-headed households, for simplicity this table has not been disaggregated for male and female household heads.
* Actual practice measured for the long rains season of 2013.

Once the grain is dried and bagged, access to improved storage facilities is another critical step in ensuring that full benefits of certain OFS solutions (i.e., bags) are realized. The results from the baseline data suggest that farmers have access to storage facilities, which implies that they can benefit from using these types of improved OFS. Figure 10 displays the current storage facilities used by farmers. By far, storage inside the home is the most common practice: 43% of Eastern farmers and 20% of Rift Valley farmers reported keeping a room in their home specifically for storage, while another 31% in Eastern and 23% in Rift Valley said they store their crops in the living rooms of the house (i.e., living and sleeping areas). Improved granaries with wooden walls are also fairly popular in the Rift Valley, used by 33% of farmers, while only 10% use these in the Eastern region. Eleven percent of farmers in the Eastern region use traditional cribs, while 13% use them in the Rift Valley. All other types of on-farm storage facilities, including improved granaries with wicker walls, separate storage structures, traditional storage over the kitchen fire, and baskets, are used by 4% or fewer of households.

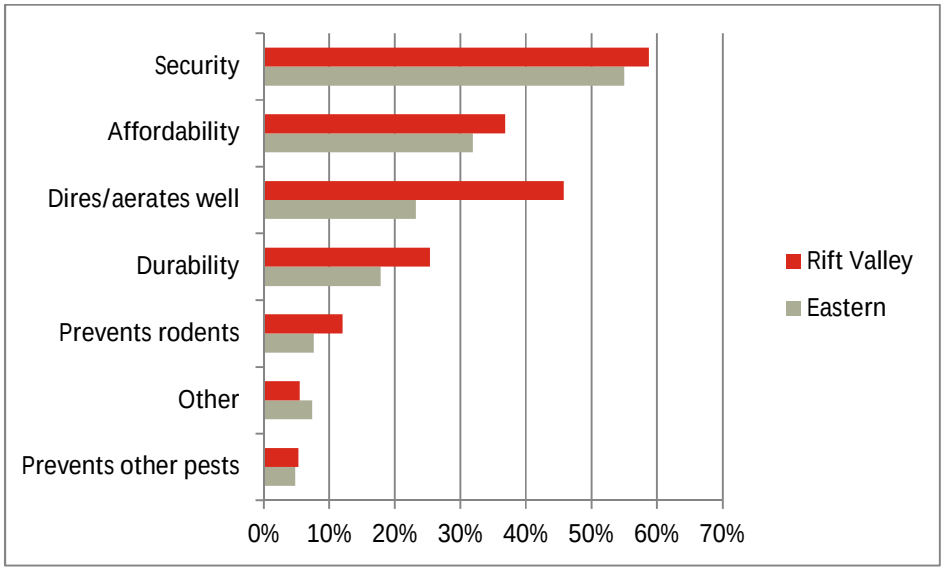
Figure 10. Percentage of baseline survey respondents reporting utilization of storage facilities



The reason a large share of farmers prefer in-home storage becomes apparent in Figure 11, which displays farmers' responses when asked for up to three reasons they prefer their current storage facility above other options. In both regions, security ranks highest (55% in the Eastern region and 58.8% in the Rift Valley region say this was a top reason); farmers apparently prefer to keep maize in the home with them in large part because they fear theft if maize is kept outside the home. Affordability is a second key reason for preferring current storage, with 31.9% in the Eastern region and 36.9% in the Rift Valley region listing it as a top reason. Rift Valley farmers also tended to rank drying/aerating as a top feature (45.8%), though only 23.2% of Eastern farmers say the same. Durability is also somewhat important, ranked as a top concern of 17.8% of Eastern farmers and 25.4% of Rift Valley farmers. Rodent and other pest prevention are both ranked among top reasons for preferring current storage by 12% or fewer of farmers in both regions. Finally, 7.4% of Eastern respondents and 5.5% of Rift Valley respondents list other reasons for preferring their current storage.

Key informant interviews with sub-county agricultural officers (SCAOs) offered additional insight into the interplay between environmental conditions, storage approaches, and the strategies farmers use to mitigate storage losses. For example, while many SCAOs reported that farmers stored grains in the house in order to reduce the risk of their grain stores being stolen, these officers also revealed that this practice causes its own problems due to inadequate ventilation that increases storage losses due to too much moisture. This is exacerbated by the poor post-harvest conditions such as untimely rains that many of them identified, which preclude farmers from drying their grain adequately before putting it into storage. Likewise, while farmers were reported to dust with chemicals to mitigate pest problems (such as weevils and LGB), numerous SCAOs observed that the chemicals were often either ineffective or incorrectly applied.

Figure 11. Percentage of baseline survey respondents reporting various reasons for preferring their current storage facility



Note: figures do not sum to 100% because respondents were asked to list up to three reasons.

Overall, the baseline results suggest that there is significant room for improvement in the knowledge and practices around post-harvest storage. Although farmers understand the importance of drying grain, almost all employ rudimentary practices to test moisture. They also are not aware of improved OFS solutions and do not use them. Our evaluation will assess whether the pull mechanism piloted by AgResults leads to an improvement in not only the adoption of OFS, but in the knowledge and adoption of other best post-harvest handling practices.

Gender-differentiated results: Female-headed households lose a lesser proportion of stored crops during storage. This implies that these households may have found relatively more effective strategies to mitigate storage losses than male-headed households. At the same time, however, despite the fact that female-headed households are much less likely to have been exposed to or to use improved OFS of any type in both regions (Table 10), in the Rift Valley female-headed households actually utilize improved OFS (specifically, PICS bags) at higher rates than male-headed households (Table 11). This suggests that there may be strong latent demand for improved OFS among female-headed households in the Rift Valley, as exposure (combined with access) leads to disproportionately greater uptake among those households relative to male-headed households in either region or female-headed households in the Eastern region. Thus, while lesser losses among female-headed households could imply potentially lower financial benefits to uptake among women (as observed in Section 3.2), it may be that non-financial benefits such as reduced labour burden and a preference to avoid pesticides will drive potentially strong uptake among female-headed households if other critical constraints (such as awareness and access) are addressed.

4.3 Evaluation Question 3: What has been AgResults' impact on smallholder income?

To answer this evaluation question for the Kenya pilot, we will assess the impact of the AgResults pilot on maize revenue rather than smallholder income. This is because we need recall data for the three time points (2011, 2012, and 2013) to establish the baseline trend in this outcome. It is not feasible to obtain reliable estimates of costs of production or to fully account for all sources of smallholder income using recall data. Using maize revenue as our primary proxy for household income allows us to make use of a relatively reliable and single-source measure of the amount households earned by selling one product. Maize revenue is a reasonable proxy because a large majority of the farmers in the region grow maize and the key mechanism by which the pilot will impact smallholder income is through improved prices for the grain. We expect adoption of OFS to lead to an increase in smallholder incomes if farmers are able to store their grains without fear of post-harvest loss and to sell them when prices are higher rather than selling the grain right after harvest when prices are low. The main impact on cost will be the higher prices for the improved OFS on which we have information. Of course, in the long run farmers' incomes may increase because they may invest more in farming if improved OFS leads to better returns, and farmers may also gain from income from other grains. To this extent our estimates will be a lower-bound estimate of the true impact.

Interviews with key actors during the IQA stage by both our quantitative and qualitative design teams suggest, however, that farmers may invest in improved OFS technologies initially to enable greater own consumption and/or reduce pesticide application to grains. This means that the main benefit of the AgResults pilot could be in the availability of grains for own consumption, and the reduction in own consumption of pesticide, elements not revealed by measuring smallholder income (or its proxy, maize revenue).

Although we intend to conduct a SITS analysis for both maize and food security outcomes, in this report we present the baseline trends for smallholder income only. We will provide the baseline time trend for food security after the intermediate survey is completed in May 2015. In the intermediate (second baseline) survey we will collect the complete data needed to develop the time trend—specifically, information on harvest date for recall periods to assess the number of months that their grain lasted.

Maize production and sales: To set the stage for assessing the baseline trend in maize revenue, we first present the maize production and sale statistics for the 2013 long rainy season (Table 13; long rainy season data refers to the seasons with harvests occurring July-August in the Eastern region and October-February in Rift Valley – refer to Appendix A for more information on the timing of agricultural seasons). Both maize production and sales figures are significantly higher in Rift Valley than in the Eastern counties. In the Eastern region, households reported producing an average of 358.2 kg of dry maize and 48.6 kg of green maize in the 2013 long rainy season, while in Rift Valley households averaged 1,184 kg of dry maize and 70 kg of green maize. Less than 17% of farmers in the Eastern region reported selling any maize, while about 41% in Rift Valley reported selling maize. In both regions, households tended to have one major maize sale in the season, with an average of 1.1 sales in the Eastern region and 1.3 sales in Rift Valley. In the Eastern region, households said they sold an average of 101.3 kg of maize in their largest sale (which is nearly always their only sale) if they sold any maize, and in Rift Valley they sold an average 546.8 kg if they sold any. (The reason that the average number of bags sold is higher

than the average number produced is that the number sold is reported only for those who sold any.) There are few differences by gender of the household except in the amount of maize sold in Rift Valley, where male-headed households sold an average of 597.9 kg and female-headed households sold an average of 291 kg.

Table 13. Maize production and sale reported by baseline survey respondents, for the 2013 long rainy season (sample averages except where noted)

	Eastern			Rift Valley		
	Total	Male HH head	Female HH head	Total	Male HH head	Female HH head
Dry maize produced, long rains 2013 (kg)	358.2	363.7	340.1	1184.6	1253.9	835.8
Green maize produced, long rains 2013 (kg)	48.6	50.0	43.8	70.2	71.0	66.2
Maize kept for household consumption	242.6	247.1	228.0	566.5	571.9	539.2
Household sold any maize (%)	17.0%	17.1%	16.6%	40.8%	40.9%	40.7%
No. of separate times household sold maize	1.1	1.1	1.1	1.3	1.3	1.1
Total quantity of maize sold in largest sale (kg)	101.3	102.7	97.0	546.8	597.9	291.0
Sale price for largest sale (KES/kg)	30	30	31	28	28	28
Sale price for largest sale (KES/90 kg bag)	2,696	2,673	2,775	2,551	2,556	2,530
Yield (kg/ha)	3,507	4,365	710	1,864	1,900	1,688
Maize revenue, long rains 2013 (KES)	2886	2950	2677	15343	16836	7878

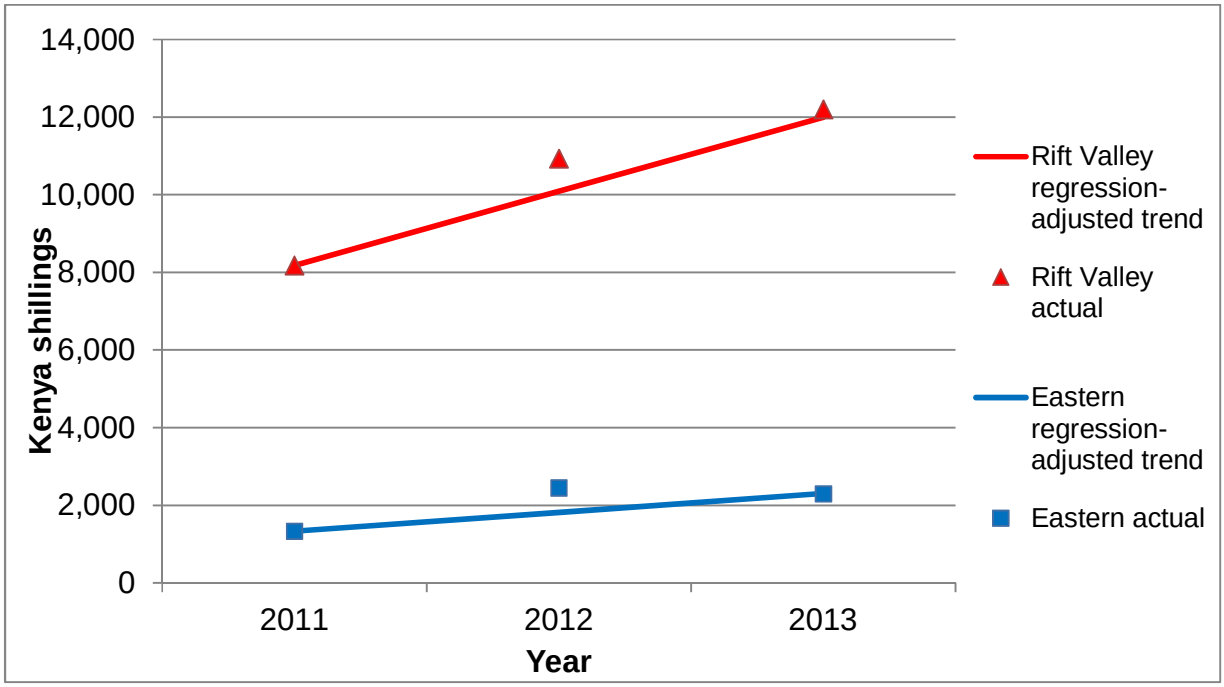
Notes: Dry maize refers to maize that was dried and shelled prior to sale or storage.
Green maize refers to maize that was sold without such processing.
Number of separate sales and quantity sold in largest sale apply only to households that sold maize.
Yield figures may vary due to intercropping.

Baseline time trend: To establish the baseline trend in maize revenue, we estimated Equation 1, with maize revenue as the dependent variable (measured in Kenyan shillings, in 2010 prices)[16]. This outcome measures the revenue that each farmer reported receiving from selling maize, calculated by multiplying the reported sale price of maize per kilogram and the reported number of kilograms of maize sold per year following the 2011, 2012, and 2013 long rainy seasons. The coefficient on the time variables gives the rate of change in maize revenue over time. Figure 12 displays the estimated maize revenue trends for each region, using a line created from the average maize revenue in 2011 and the regression coefficient on *time* to create the 2012 and 2013 time points. As can be seen, the Rift Valley trend line exhibits a steeper slope (higher rate of increase in revenue) than the Eastern region line, and starts from a much higher average revenue in 2011. The results suggest that inflation-adjusted maize revenues in the Eastern region were increasing by about KES 485 (2010 prices) on average annually, while the maize revenues in the Rift Valley region were increasing at a much higher rate, at an average of KES 1,907

[16] Adjusted using the GDP deflator from the World Bank national accounts data, and national accounts data files from the Organisation for Economic Co-operation and Development See http://data.worldbank.org/indicator/NY.GDP.DEFL.KD.ZG.

(2010 prices) per year[17]. The difference in trends in between the two regions is statistically significant at the 1% level. The full regression results are presented in Appendix H.

Figure 12. Maize revenue trend lines for Eastern and Rift Valley regions, fitted by regressing yearly figures reported by baseline survey respondents[18]



Overall, the regression analysis of inflation-adjusted maize revenue suggests that there was an upward trend in smallholder income over three years preceding the pilot, in both regions, with a steeper trend in the Rift Valley region. However, we should take into account that 86% and 67% of households in Eastern and the Rift Valley counties across all years, respectively, report zero maize revenues, so much of the slope is influenced by the relatively small proportion of households that do have positive maize revenues. When we disaggregate the sample by each region, the regression results demonstrate an upward trend in outcomes over the three years, with Rift Valley exhibiting a larger positive trend.

Disaggregation by Gender and Poverty: We find that there is no statistically significant difference in trends between male-headed and female-headed households in the Eastern region, but there is a difference (albeit only at the 10% significance level) in the Rift Valley region, with

[17] Both coefficients are significant at the 1 percent level.

[18] The regression coefficient (representing a linear increase in maize revenue of 1,907 Kenya shillings per year) in the Rift Valley region shows the true time trend to the best of our information. However, particularly given only three time points to date, it is possible that the apparent increase reflects annual fluctuations in addition to the true underlying time trend. Collecting data from one more pre-intervention time period, as we are planning to do during the second phase of baseline data collection, will help to temper the effects of any annual fluctuations on the trend line. It should also be noted that the increase in 1,907 Kenya shillings per year is still relatively small when compared to the annual total household income our survey found in the Rift Valley region of 197,510 Kenya shillings.

data for male-headed households exhibiting a strong upward trend while female-headed household data do not show a statistically significant trend. These results potentially open the opportunity for the OFS interventions to make a stronger positive impact on households with female heads. When we disaggregate by poverty levels, we find that the Eastern region's very poor households exhibit a trend in maize revenue that is very different from the non-poor, with the non-poor households exhibiting a strong positive trend in outcomes over the baseline period, while very poor households do not have a statistically significant trend. However, the Rift Valley does not exhibit a statistically significant difference between its very poor and non-poor households, with both groups showing positive trends.

It should be noted that the maize revenue outcome may be susceptible to a form of recall bias, in which the accuracy of the smallholder farmers' response is directly correlated with time. This issue is more prevalent in maize revenue outcome than in OFS technology adoption outcome because the latter is a more discrete and distinguishable event that departs from the normal practice. In the case of maize revenue, the prices and number of packages of maize sold, if not recorded, accurately may be susceptible to attenuation in earlier time points, leading to a downward bias earlier in time. This type of bias is evident in other forms of recall over longer periods of time using survey information (Bound, Brown, & Mathiowetz, 2001), and may make the reported trends in maize revenue provided here steeper than the true trends.

Baseline food security status: The biggest impact of the pilot may be on the amount of grain available to households for their own consumption. Even though nearly all households surveyed at baseline reported cultivating maize in the 2013 growing season, about 58% of households in both regions ran out of maize between harvests (i.e., they consumed all the maize they grew and kept from the last harvest before their next harvest). Consequently, 53% of households in the Eastern region and 62% of households in the Rift Valley region report purchasing maize for consumption during the past year. In the Eastern region, households who purchased maize purchased about 260.8 kg and spent about KES 9,459, while households in the Rift Valley who purchased maize bought 330.1 kg on average and spent an average of KES 12,133 (see Table 14).

Table 14. Maize provisioning in the past year reported by baseline survey respondents

	Eastern			Rift Valley		
	Total	Male HH head	Female HH head	Total	Male HH head	Female HH head
Percentage of households that ran out of previous season's maize before LR2013 crop was harvested	57.9%	56.8%	61.2%	58.4%	57.7%	62.0%
Percentage of households that purchased any maize for consumption during past year	53.0%	52.2%	55.7%	62.0%	61.6%	64.1%
Amount of maize purchased for consumption during past 1 year (kg) (average for those making purchases)	260.8	265.0	247.9	330.1	327.7	341.5
Total spent on maize in past year (KES) (average for those making purchases)	9,459	9,592	9,051	12,133	12,081	12,380

The survey also elicited households' food security situation more generally by asking them to list the months in which they were food insecure during the past 12 months. Responses to this question suggest that hunger and food insecurity are a concern for less than 10% of the households. First, the survey asked respondents about months when any household member went at least 24 hours with no food. As shown in Figure 13, the vast majority of respondents (83.5% in Eastern and 82% in Rift Valley) said that did not occur at all during the past year (represented in the figure below as month "None.")

The next chart, in Figure 14, shows the proportion of households reporting that at least one member ate fewer or smaller meals than needed at any point in a month. Most households (71.3% in the Eastern counties; 65.1% in the Rift Valley counties) went the whole year without any months where they had to face this issue. However, in the Eastern region the months of September and October were the most food insecure, with 10.3% of households reporting that members ate fewer or smaller meals than they needed (in parallel, 4.6% of Eastern households also reported that at least one member went 24 hours with no food during September and October; see Figure 13). In Rift Valley, the most food-insecure months were January (when 14.2% of households said at least one member ate fewer or smaller meals than needed and 6.2% said members went 24 hours without eating) and February (when 10.4% of households had members who ate less than needed and 4.7% of households had members who went 24 hours without eating).

Figure 13. Proportion of households where at least one household member went at least 24 hours with no food (by month)

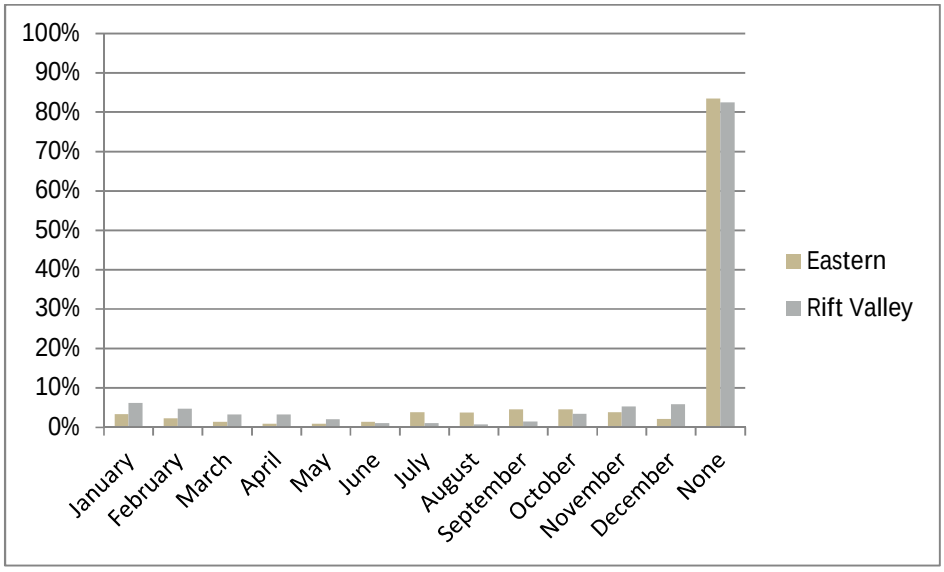
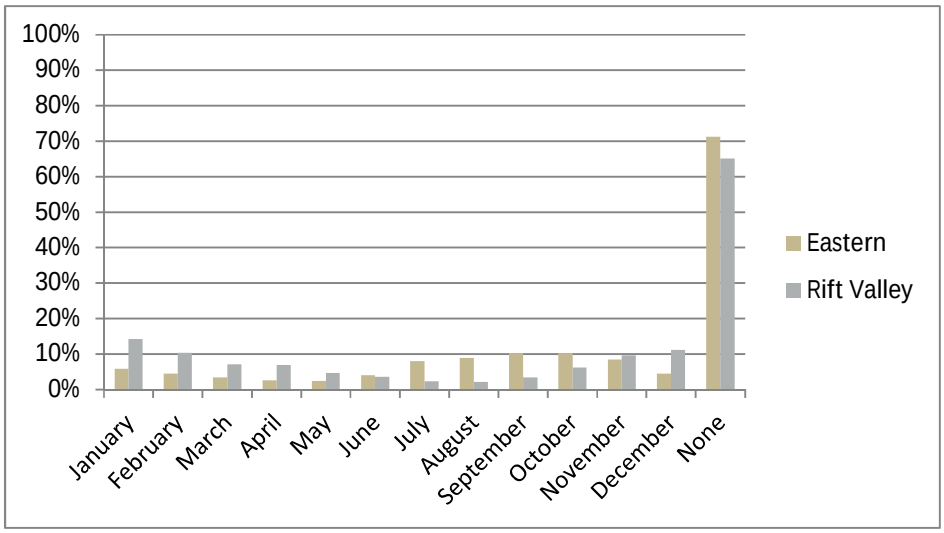


Figure 14. Proportion of households where at least one household member ate fewer or smaller meals than needed (by month)



One of the evaluation's challenges will be to establish a time trend on the food security over the baseline period, including the subsequent months covered by the upcoming intermediate (still pre-pilot) survey, using recall data. Leveraging the lessons learnt from the current survey, we expect to refine the questions and make another attempt to obtain this information reliably.[19]

[19] The baseline survey instrument contained questions on both the month the household completed its maize harvest and the month during which the household ran out of maize that had been stored for consumption following the 2013 growing seasons. The food security outcome on how long stored maize lasted was to be constructed by subtracting the harvest month from the run-out month. However, these measures proved problematic for two reasons: 1) farmers sometimes misunderstood the question on the month they ran out of maize, reporting the month

That said, farmers may make errors in recalling when they ran out of maize for consumption. Therefore, we are prepared for the possibility that it may not be feasible to assess post-pilot impact on food security using a SITS methodology. We will develop alternative methods for studying food security if needed once the intermediate survey's data on an additional pre-pilot year become available.

Gender-differentiated results: Table 13 above also differentiates maize provisioning by gender. As can be seen, in the Eastern region all households demonstrate a strong subsistence orientation, with approximately two-thirds of maize production retained for household consumption in both female-headed and male-headed households. In Rift Valley, female-headed households also retain approximately two-thirds of their harvest for own use. However, male-headed households appear to be more market oriented, reporting retention of less than half of their harvests for household use (see Table 13). Despite this contrast, with female-headed households reporting lower total maize production, they also report running out of maize stocks sooner than male-headed households in both regions. As noted above, there were no significant differences in the maize revenue trend between female-headed households and male-headed households in the Eastern region, but in Rift Valley the male-headed households exhibited a stronger positive time trend compared to the female-headed households.

4.4 Evaluation Question 5: What evidence exists that the effects of the AgResults pilot will be sustainable in the medium to long term?

The SCP analysis, used for Evaluation Question 1, also offers insights into the potential sustainability of the pilot's effects with respect to private sector engagement in the market. Presuming that the pilot effectively stimulates private-sector engagement in the market, the essential sustainability issue is whether as part of that impact conditions have been created for private sector players to continue to invest and act in the market once the pull mechanism incentives are discontinued.

Baseline results offer some insight into the question of whether the pilot's impact on private sector engagement in the market, if any, will be sustained following the conclusion of the pilot. There was a perception among private sector actors that smallholder cereal farmers offer a latent but strong potential market. OFS suppliers' stated intent to invest in this market implies the pilot's potential sustainability.

Firm strategies to enter the market are grounded in a sound understanding of market conditions, including both farmer demand conditions and what will be required to get distributors involved in the market. While there are two general channels by which firms intend to distribute improved OFS products, the OFS products themselves and the firms' experience with the OFS market in general vary widely, as does the timing and scale of market entry that they anticipate. This implies that, even if a sustained and sustainable market for improved OFS emerges as a result of the AgResults pilot, there may be some attrition, withdrawal, or disinvestment of individual firms in the market, particularly if there are first-mover advantages to earlier market entry.

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they ran out before the harvest (i.e. from the season previous to the reference season instead of from the reference season itself); and 2) farmers and enumerators may have erroneously entered the year in which maize ran out, causing it to seem as if maize ran out before it was harvested. Because of this data issue, we will re-ask this question in the 2015 survey and present results for this outcome in our amended report.

Potential implementers' product development, procurement, and merchandising strategies all entail significant investment in the market, also suggesting a seriousness of intent that supports their claims that they see the OFS market as having high potential. These investments represent fixed (and sunk) costs that, if realized, will defray per-unit sales costs by establishing channels and mechanisms for low-cost procurement and distribution of improved OFS at scale and on an ongoing basis.

Given firms' intent to invest in the market, and the role AgResults is reported by firms to have in catalysing this investment, the emergence of a sustained market can be expected to rely on realization of firms' sales goals. These in turn will depend heavily on effective promotion of OFS solutions among farmers. At the local level, the emergence of a sustained market—should it occur—is likely to be concentrated in areas where smallholder farmers are exposed to improved OFS promotions. These are likely to be famers who shop at participating commercial distributors or are members of organizations that distribute them and who have the financing available to acquire improved OFS. This implies that sales will be strongest in higher-potential agricultural areas, which are identified as areas where maize or cereal production is high and is produced for sale, and where implementers expect to focus their marketing. Even if the improved OFS does not reach the poorest farmers at the outset, however, their exposure to and uptake of improved OFS may grow as the solutions become commonplace. In contrast, low-potential agricultural areas that are not the focus of implementers' investments (or do not remain the focus) and are home to generally poorer farmers may lack the "anchor" of wealthier smallholder farmers who will bring supply into the vicinity in order to create continued access of poorer smallholders to improved OFS. This could have important implications for areas with weaker cereal and grain production systems and where lower-resource farmers predominate, such as the Eastern region, as it could imply these areas will be neglected by the OFS suppliers.

Given the potential for poorer/lower-potential agricultural areas to be underserved by the market, then the market's performance may ultimately be weakened in terms of the ability for poorer farmers to access improved OFS through the market. This may also hold for women if they are less likely to participate in organizations or frequent agro-input suppliers, particularly if they have lower resources.

A related consideration in the long-term sustainability of the pilot impacts, if any, is the extent and depth to which the pilot affects the awareness and knowledge of the farmers. Farmers need to have a broader understanding of the improved post-harvest storage handling practices such as drying and testing of moisture to realize the full benefits of OFS. If the OFS suppliers and distributors generate broader awareness about these aspects, then it will increase the likelihood of the impacts sustaining for a longer period.

4.5 Evaluation Question 6: What is the evidence on the scale of any effect on private sector investment and uptake and on the cost-effectiveness of AgResults as an approach?

This question is best answered after endline data are available to assess the impact and cost-effectiveness of the pilot. In answering this question, we will compare the firms' projections about the scale they expect to reach and what they actually did. Since the pilot is not yet launched and the firms are continuing to refine their strategy, we do not yet have adequate data to present the firm's expectations.

4.6 Evaluation Question 7: What lessons can be learnt about best practices in the design and implementation of agricultural pull mechanisms?

In order to begin exploring this question, we asked the potential implementers in mid- to late 2014 about their experience, to date, with the AgResults pilot or the market the pilot sought to promote. These interviews occurred when AgResults had begun communicating the details of the pilot; however, the pilot design was not fully complete, especially the details on verification. As noted in Section 1.2 above, the potential implementers experienced many changes in the planned design and planned launch time, which impacted their responses to these questions. These responses offer a number of insights that can be taken into consideration in the design of future incentive-based interventions, although some of these insights point to a move away from a pure "pull" design. Undoubtedly, the potential implementers' perspectives and lessons learnt will evolve over time as we check back on this topic over the course of the evaluation.

First, in the early stages, several potential implementers expressed an interest in having the pilot play a role in a generic marketing campaign that would help facilitate the development of the market. Such an intervention would be a clear case of moving away from the kind of pure pull design AgResults concentrates on. Indeed, market incentives could lead implementers to come together and create such a campaign on their own. However, the competitive nature of the pilot—combined with the diversity of the potential implementers, their divergent scales of operation, different timing of market entry across firms, and lack of familiarity with one another—mean that potential implementers do not consider such a collaboration to be a realistic goal or expectation within AgResults itself. Several potential implementers shared the perspective that a generic marketing campaign could have helped to overcome one of the major impediments to the development of the market (low awareness), thereby increasing the potential impact of the pilot (sales of improved OFS) while not advantaging any individual competitor.

Likewise, potential implementers highlighted a number of areas where their engagement in the market was constrained and that the pilot could, arguably, have facilitated without benefitting any individual player. Examples include helping to facilitate or fast-track KEBS review of the OFS solution and third-party testing of the OFS solution with results being published in comparative fashion so that potential buyers or distributors could benefit from objective information about the options. Such interventions would arguably not compromise the pull nature of the pilot mechanism in that it would still be up to the individual implementers to tackle the major R&D, procurement, and merchandising tasks that underlie effective engagement in the market. As limited duration or one-time interventions, such measures could also have helped to establish a professional standard or examples that implementers could have built on in their own future marketing activities.

Capital, both operating and investment, was an oft-cited constraint on potential implementers' involvement or expansion in the market. Several firms suggested how the pilot could help to overcome this constraint. One suggestion was that the pilot could provide a documentary letter to implementers that they could leverage to access bank financing. It was also suggested that some sort of up-front grant (similar to the business plan competition used in the Zambia pilot) could motivate and facilitate entry to the market.

To summarize the essence of the issue, the pilot was designed to overcome the primary constraints that inhibit engagement in the market, but those firms whose engagement in the market was motivated by the pilot then ran into an array of secondary constraints (limited

demand, access to capital, regulatory delays) that some felt impeded their ability to respond fully and effectively to the market opportunity.

Several firms were critical of the structure of the incentive, in particular the payout of a large portion of one reward after four years (for development of a LGB-proof storage option). They pointed out that four years is so far outside the business planning and budgeting cycle that the incentive lost much of its attractiveness. Earlier payouts, staged throughout the duration of the pilot, were suggested as an alternative that would be more attractive.

Verification of sales is a major issue to a number of the potential implementers as well, and at the time of the interview several stated that they would wait to see how the verification issue is resolved before they definitively decide to participate in the pilot. Most potential implementers were concerned about verification from the standpoint of how effectively their sales would be tracked (which would be tied to their reward) and the extent to which they would have to either bear some of the verification costs or compel their distributors to track sales on their behalf. Another firm expressed a general concern over the effect that the verification process and reporting in general could have on their long-term potential in the market. For example, if they felt the verification methodologies utilized did not accurately represent their performance, then in addition to losing out on the reward, they were concerned that their product might appear to be less successful than it really was.

Several potential implementers were also constructively critical of the evolution of the pilot structure, particularly the extended duration of its evolution, shifting responsibilities among different parties, and the interplay between its business and development orientation. These criticisms were at times somewhat contradictory in nature, highlighting the complexity and nuance involved in developing and implementing a pull mechanism in the agricultural and economic development context, particularly given the innovative nature of a pull strategy. For example, it was suggested that the pilot evolved at "development speed" rather than at "business speed" (i.e., that it follows donor rather than private sector scheduling). There was concern that transitions between parties involved in business plan development (Dalberg), early implementation (Secretariat), and pilot implementer (ASI) led to a loss of momentum, causing uncertainty among potential implementers that led them to delay their investment trajectory. These perspectives were tempered by the recognition of the innovative nature of the pull mechanism as well as an appreciation of the valuable periodic engagement between the different parties responsible for developing and implementing the pilot and the potential implementers. A key suggestion that emerged was to increase the frequency of communications and consultations, particularly through activities that bring different implementers together to discuss issues (rather than separate meetings with individual implementers), in order to encourage more efficient solicitation of private sector input on the pilot's structure and evolving issues.

Finally, the point was made that by jump-starting the development of a nascent market, the pilot has the potential to overwhelm or undermine investments that pioneer firms have already made to develop the market. These investments include forays into development of demand, as well as development of informational materials or advertising activities. A counter argument could be made that pioneer firms would be particularly well positioned to participate in the pilot Furthermore, even with the pioneering firms' activities, the market was targeted due to its state of underdevelopment such that any loss to the pioneering firm could be seen as either justifiable "collateral damage" or the natural outcome of a market's development. Nonetheless, there is

value to at least recognizing that if there is any private sector activity in the market, the pilot could lead to there being some losers among the winners.

5. Evaluation next steps

Following baseline data collection, the evaluation team will continue to monitor the pilot implementation as part of our ongoing qualitative assessment. This will consist of regular communications with the Pilot Manager, the Secretariat, DFID, and the Steering Committee to keep track of any issues that arise, their importance to the pilot's implementation, and how they are eventually resolved. This will continue up to the point of endline data collection in 2019 (assuming extension of the evaluation contract, as the pilot will run for three full years after it begins in 2015).

The delay in pilot implementation has implied that another round of quantitative data collection right before implementation begins is necessary to fully elaborate the baseline time trends that are important to ensure the robustness of the SITS analysis. We expect to conduct this survey in May and June 2015, revisiting the same households who participated in the first baseline survey. Based on the data collected in the next round, we will revise this report to include updated baseline time trends incorporating the additional time point, and the projections for the key outcomes through the end of the pilot period based on time trends, which will serve as the counterfactual. We will also include the baseline time trend and the projections for the food security outcome using the data we gather from updated questions in the next round. In addition, we will include the baseline trends of an unaffected or untreated outcome—maize yield—to remove any bias that arises from confounders that skew the unaffected outcome in a like manner to the affected outcomes as described in the evaluation design report.

In or around May 2019, we will conduct the endline survey with the same sample of households surveyed at baseline along with qualitative data collection for other stakeholder groups. Based on this endline data collection, we will present an impact evaluation report by the end of 2019 addressing each of the evaluation questions. We will conduct a sustainability assessment in the spring of 2020, assuming extension of the evaluation contract.

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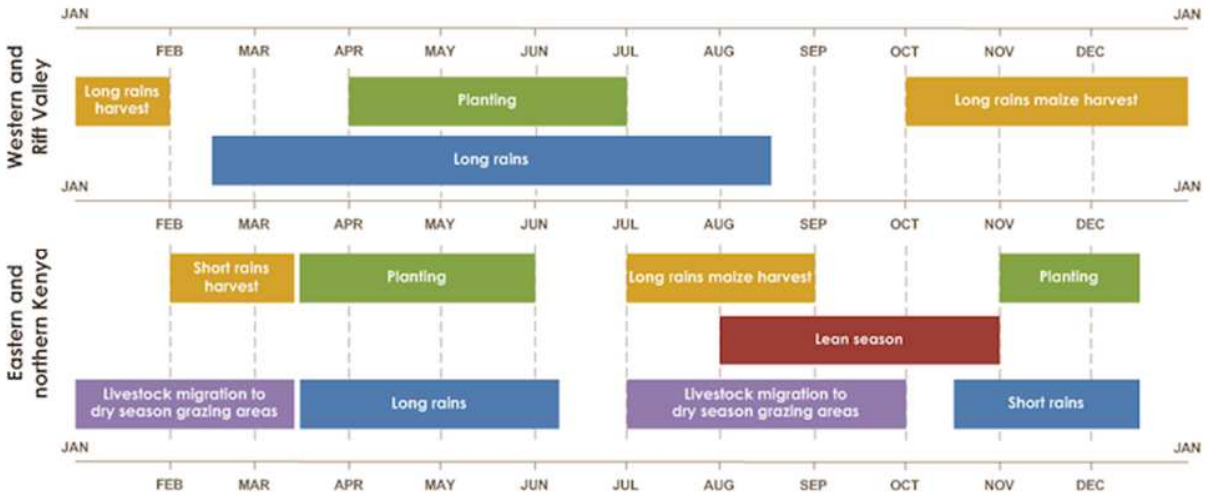
Appendix A: Seasonal calendar for maize in the Eastern and Rift Valley regions



Appendix B: Qualitative (SCAO, farmer, commercial distributor) questionnaires

Kenya sub-county-level (SCAO) survey

Interviewer and interview data

Name of interviewer

Was interview sound-recorded?
Yes
No

Interview date

Interview start time

Respondent and county information

Respondent name:

Respondent position SCAO Other _____

Contact information:
Telephone
Email

Location:
Region
County
Name of sub-county

Storage use, issues, and options

Are you familiar with the grain storage issues that farmers in your area face?	
Very familiar	
Somewhat familiar	
Vaguely familiar	
Not familiar at all	

How severe are the following storage issues?

	Severe	Significant	Minor	Not a problem at all	Don't know	Comments
Weevils						
Rodents						
LGB						
Aflatoxin						
Mold						
Theft						
Poor conditions for post-harvest management of grain						
Other						

What storage solutions do smallholders use for cereals and grains in area?

	What share of smallholders use option?	What is most common source?				
	%	MoAg	NGO	Membership organization	Commercial supplier	Project
Poly-pro bags w/ or w/o chemicals						
Traditional and/or home-made storage						
Pesticide impregnated bags						
Hermetically sealed plastic bags						

Hermetically sealed plastic tubs or bins						
Metal Silos						
Community storage banks						
Private storage including WRS						
NPCB						

What storage solutions do smallholders use for cereals and grains in area? (continued)

	Where is source located?	Specify source and contact info	
	Describe	name	phone/email
Poly-pro bags w/ or w/o chemicals			
Traditional and/or home-made storage			
Pesticide impregnated bags			
Hermetically sealed plastic bags			
Hermetically sealed plastic tubs or bins			
Metal Silos			
Community storage banks			
Private storage including WRS			
NPCB			

Any active ag-related initiatives? Specify project, organization, and what they do that is related to ag and/or storage.

	Project name	Organization	Locations	Ag and/or storage-relevant activities	Contact info	
Project 1						
Project 2						
Project 3						
Project 4						
Project 5						

Any member-based agriculture organizations (farmers groups, etc.) that might serve as a distribution channel for on-farm storage?

	Organization name	Locations	Describe ag and storage-relevant activities	Contact info
Organization 1				
Organization 2				
Organization 3				
Organization 4				
Organization 5				

Any questions or comments?

Interview end time: _____

Farmer questionnaire

Screening questions

What area (of all agricultural crops) did you cultivate during the previous main production season? (indicate units in next question)

	Quantity	Units					specify
		acre	ha	m2	Other (specify)		
Area cultivated							

Do you plant maize and grains primarily for your household's consumption, for the market, or equally for both?
Household consumption
Market
Equally for both
Other (specify) _____
Don't plant maize/cereal/grains (terminate interview)

In 2013, approximately what share of your household's income came from sale of agricultural products that you cultivated? (please record as a %)

Does household reside at/near the farm or elsewhere?
At farm
Elsewhere
Other (specify)_____

Is the household headed by a male, female, or jointly?
Male
Female
Jointly
Other (specify)_____

How far is household located from:						
	Quantity	Unit				Specify
		Kilometers	Minutes walking	Minutes driving	other	"other"
Nearest tarmac road						
Nearest main market						

Interview data

Interview date

Interview start time

Respondent information

Respondent ID number

Location:
Region
County
Sub-county
Location/Ward/Village

Gender of respondent
Male
Female

How many people live in the household ("eating from same pot" or otherwise part of the household economy)?

What is place of respondent in household relative to head of household

Does anyone from the farm-household belong to a farmers' organization or other membership organization?

Yes

No

If yes (belongs to organization), identify type of organization, and briefly describe purpose/activities of organization

Type of organization

Purpose/activities

Potential means to access enhanced OFS?

Characterization of respondent's household cereal/grain production and sales activities during most recent major season

In the most recently completed major production season:		
What area cultivated?	Area	
	Units	
Harvest month	Month	
Quantity harvested	Quantity	
	Units	
	Kg/Unit	
Sale month	Month	
Quantity sold	Quantity	
	Units	
	kg/unit	
What motivated sale?	Pay school fees	
	Cash for other expenses	
	Buyer availability	
	Pay debts/loans	
	Attractive price	

	Fear of storage loss	
	Other (describe)	
What was your most important cereal/grain crop?	Maize	
	Sorghum	
	Millet	
	Rice	
	Other (describe)	
Who did you sell to?	Didn't sell	
	Trader	
	NCPB	
	School/institution	
	Contract buyer	
	Individual/HH	
	Miller	
	Other	
Sale arranged before harvest?	Yes/No	
Buyer provided financing or inputs?	Yes/No	
Was product picked up or delivered?	Picked-up or Delivered	
How much paid?	Ksh/unit	
	kg/unit	
How much did you keep for household consumption?	Quantity	
	Units	

	kg/unit	
When did you run out of grain for household consumption?	Didn't run out	
	Month	
Did you have to buy grain for your household's use?	Yes/No	
	KSH/unit	
If yes, how much did you pay?	kg/unit	

Current post-harvest and storage practice and issues

How do you prepare grain for storage?
Cobs dried directly on ground
Cobs dried on tarp on ground
Cobs dried in crib
Other _____
n/a

How do you know when the maize is dry enough to store?
Moisture meter
Sound grain makes
Biting
Glass bottle with salt
Other _____
n/a

How do you shell the maize?
By hand
Beating
Machine

Other

n/a

What storage is used?

	Most important		2nd most important		3rd most important	
	Type	Brand	Type	Brand	Type	Brand
Poly-pro/gunney bag						
Traditional or self-made storage						
Pre-treated poly-pro bag						
Hermetically sealed plastic bag						
Hermetically sealed plastic tub or bin						
Metal Silo						
Community grain bank						
Private warehouse						
NCPB						
Other						

For each of the top three types of storage utilized:

Is this used for grain for home consumption or sale?

Consumption Sale Both

First option:

Second option:

Third option:

Following the last major production season, how much of the grain you stored was lost due to all storage problems? (%)

Storage as a constraint

	Severe	Significant	Minor	None	Unknown	Comments
In general, how significant a problem/constraint does storage present?						
Weevils						
Rodents						
LGB/Osama						
Aflatoxin						
Mold						
Theft						
Poor post-harvest and storage conditions						
Other						

Experience with enhanced OFS.

Ask the following questions for each type of enhanced OFS that the household has used.

		1st type of enhanced OFS	2nd type of enhanced OFS	3rd type of enhanced OFS
	Agro-vet			

Where did you acquire the storage from?	Specialized vendor/distributor			
	Other intermediary			
	Artisan			
	Extension worker			
	Farmer or other membership org			
	Community devt project/NGO			
	Other (specify)			
When were you first exposed to it?	year			
When first used?	year			
How many purchased?	number			
What capacity purchased?				
How financed purchase	cash saved			
	loan from family/friends			
	financing from OFS supplier			
	financing from membership org			
	financing from ag output buyer			
	Other (specify)			
How reached decision to purchase?				
Who responsible for management of unit	Male adult			
	Female adult			
	Joint			

	Other (specify)			
What store in unit	Maize			
	Sorghum			
	Millet			
	Rice			
	Legumes/Oilseeds			
	Water			
	Other (specify)			
What motivated purchase?	Cleaner grain			
	Sell own for higher			
	Store own to consume			
	Buy grain to sell			
	Buy grain to consume			
	Recommended			
	Promotional price			
	Other (specify)			
How performed	What liked?			
	What disliked			
Who in hh is primarily responsible for management of grain in this storage?	Adult male			
	Adult female			
	Joint			
	Other (specify)			

Ask the following questions for each type of enhanced OFS that the household has used.

		1st type of enhanced OFS	2nd type of enhanced OFS	3rd type of enhanced OFS
Were you already a client or associate of this supplier?	Yes /No			
Reflections on source of OFS				
Services included with purchase	Training			
	Delivery			
	Set up			
	Maintenance			
	Finance			
	Other (specify)			
Services available at extra cost	Training			
	Delivery			
	Set up			
	Maintenance			
	Finance			
	Other (specify)			
How have activities changed?				
Looking forward--continue to use/purchase more?				

What is the respondent's exposure to and perspective on different storage options?

		Pesticide impregnated bags	Hermetically sealed plastic bags	Hermetically sealed plastic tubs or bins	Metal Silos	Community storage banks	Private storage including WRS	NPCB
What is respondent's	Never heard of it/no exposure							
	Vaguely aware of it							

exposure to option?	Familiar with option							
	Have used (skip to next storage)							
Which of these options would respondent be interested in using? (otherwise leave blank)								
Answer only for top 3	What do you like about this option?							
	What would you store in it?							
Home consumption or sale?	Home							
	Sale							
	Both							
Source?	Agrovet							
	Specialized vendor							
	Other intermediary							
	Artisan							
	Extension worker							
	Membership org							
	Community dev project/NGO							
	Other (specify)							
How finance	Cash saved							

	loan from family/friends							
	financing from OFS supplier							
	financing from membership org							
	financing from ag output buyer							
	Other (specify)							

Ask the following questions for each type of enhanced OFS that the household has used.

	What motivates interest?								intere using
	Cleaner grain	Sell own for higher	Store own to consume	Buy grain to sell	Buy grain to consume	Recommended	Promotional price	Other (specify)	
1st type of enhanced OFS									
2nd type of enhanced OFS									
3rd type of enhanced OFS									

Any comments or questions?

Interview end time: _____

Kenya Commercial Distributor survey

Name of interviewer
Tabitha
Other _____

Was interview sound-recorded?
Yes
No

Interview date
Month
Day

Interview start time: _____

Survey number: Use this interview number to link the data entry form to the PID which you are recording separately.

Type of firm/organization
Agro-input dealer (that sells seeds and crop products such as fertilizers and protectants)
Hardware (that sells farm implements)
Membership organization_____
Other_____

Is firm formally registered?
Yes
No
Unknown

Is respondent male or female?

Male
Female
Don't know

Is firm owner/operated?
Yes
No
Unknown

Is respondent owner or employee or other?
Owner
Employee
Other_____

Where is firm headquartered?
Nairobi
Other_____

What locations does firm/org work in?
Regions
Counties
What specific sub-counties and locations does firm distribute to?

Does firm wholesale, retail, or both?
Wholesale only
Wholesale primarily but also some retail
Retail only
Retail primarily but also some wholesale
Both equally
Other_____

Is firm part of a chain or franchise?

Chain

Franchise

No

If yes, how many outlets does firm operate

If wholesaler, how many outlets does it distribute to (including those that it does not own)?

How many full-time employees does firm have?

Where does firm obtain merchandise from?

Direct from importers/manufacturers

Commercial distributor (specify which distributor and obtain contact info if possible)_____

Intermediary (indeterminate sources) (3)

Agro-input dealer in town (specify name of agro-dealer and town) _____

Other_____

Are you informed/aware of the issues farmers' face with losing grain they have stored?

Very aware/informed

Somewhat aware/informed

Vaguely aware/informed

Not at all aware/informed

How severe is the problem of farmers losing grain from storage in the area you work in?

Very severe

Significant

Minor

Not a problem at all

How severe are the following problems affecting grain losses in storage in the area you work in?

	Severe	Significant	Minor	Not a problem	Don't know
Theft					
Rodents					
Weevils					
LGB/Osama					
Mold					
Aflatoxins					
Bad post-harvest conditions					
Other					

Do you currently sell or have you ever sold any on-farm grain/cereal storage products/materials suitable to small-scale farmers' needs? Yes/No								
		Poly-propylene bags	Sisal bags	Pre-treated poly-pro bags	Hermetically sealed bags	Hermetically sealed tubs/bins	Metal silos	Other (specify)
Currently sell or once sold	Currently							
	Once sold							
	No							
Year began								
Year ended								
Brand								
Supplier								
No. sold								
Supplier arrangement	Cash							
	Consignment							
	Other							
Cost/unit in KES	50kg							
	90kg							
	100kg							
	Other							

For any OFS sold, what is included, available for extra, or "linked" with purchase?					
	Pre-treated poly-pro bags	Hermetically sealed bags	Hermetically sealed tubs/bins	Metal silos	Other
Information					
Demo					
Training					
Credit					
Delivery/set-up					
Maintenance					
Warranty/ Guarantee					
Other (specify)					

What are the typical characteristics of farmers who buy the improved storage solutions?	
	Describe
Scale of production	
Commercial vs. subsistence orientation	
New client to distributor?	
Source of financing?	
Any organizational affiliation?	
Motivation for purchase?	
Gender	
Other salient characteristics?	

For each type of improved storage carried, ask:

	Storage 1	Storage 2	Storage 3
Specify type of storage			
What were/have been successes associated with carrying this storage?			
What were/have been problems?			
If you stopped carrying it, why?			

Do you think it is a commercially viable product? Why or why not.

How do farmers who bought it differ from other farmers

If still carries: Do you intend to continue carrying it? Why or why not?

If intends to continue, do you plan any changes to how you will source, distribute, market, or price it? Describe.
Has your arrangement with the supplier of the product worked out? What has worked vs. not worked? Do you feel you have been given adequate incentive/risk protection?

Do you think the supplier will continue to market through you and similar distributors? Why or why not.

Do you think the supplier will make any changes to how it sources, distributes, or markets the product? Describe.

Have you ever been asked to sell, or considered selling, any of the above-mentioned storage options but decided against it?

Yes

No

If yes, which ones, and what drove your decision? What was your perception of the market (supply and demand) and how did that influence your decision?

	Considered carrying?		Why decided against it?
	Yes	No	describe
Pre-treated poly-pro bags			
Hermetically sealed bags			
Hermetically sealed tubs/bins			
Metal silos			
Other			

Looking forward, would you consider selling any of the improved types of storage? Which ones and under what circumstances? Who would buy it?

	Consider carrying?		If yes or maybe, what is attractive about option?	Under what circumstances would carry?	Who would be best clients?

	Yes	No	Maybe			
Pre-treated poly-pro bags						
Hermetically sealed bags						
Hermetically sealed tubs/bins						
Metal silos						
Other						

Do you have any questions or comments on the topics we've discussed? (If not, thank you for your participation.)

Interview end time: _____

Kenya maize sector expert key informant questionnaire

1. Characterize maize storage market and issues
    i. Storage options available
    ii. Storage options in use
    iii. Numbers and characteristics of storage suppliers
    iv. What are storage problems?
    v. What are potential storage resolutions?
2. What projects are going on in the area that will affect farmer practices?
3. What policies (such as government price controls, purchases, subsidies/taxes) affect the local maize economy?
4. What prevalence/role of private input distributors in the area?
5. Hypothetical exploration of the pilot interventions planned and how those might affect firm's activities in the market (if they don't have awareness of storage as an issue, no need to ask)
    a. Do they think that improving the availability of storage options to farmers would help to resolve their storage issues?
    b. Describe pilot program intervention—what are their thoughts on its feasibility and how it might affect their own business
        i. Objectives in terms of making storage available and examples of types
        ii. Structure of working through private sector
6. Characterize farm households on the basis of Farm household characteristics and livelihood strategies
    a. Household structure
        i. Household structure
        ii. Number in hh
        iii. Polygamous/monogamous
        iv. Female or male headed, if female defacto or de jure
        v. Land tenure (own, rent, communal)
        vi. Hold legal title?
        vii. Male title holder only?
    b. What are major farm-level issues
        i. Production (pests, temperature, rainfall patterns, etc.)
        ii. Post-harvest (storage, …)
        iii. Markets (access, …)
    c. What are major sources of diversity/differentiation within and between those groupings on the basis of
        i. Production and marketing
        ii. Technology use
        iii. Importance of farming in household livelihoods
        iv. Ethnicity
        v. Female vs. male household heads
        vi. Health issues (HIV/AIDS)
        vii. Access to off-farm income (including remittances)
        viii. Assets (land, etc.)
7. When does planting and harvest take place for the maize production seasons? Which is most important season?
8. How would they characterize the maize marketing chain in the area?
    a. Production

iv. Use of male/female and hired/family labor for different production activities

1. Land preparation

Male/female

Hired/family

Mechanical/manual/animal/chemical

2. Planting, weeding

Male/female

Hired/family

Mechanical/manual/animal/chemical

3. Harvest

Male/female

Hired/family

Mechanical/manual/animal/chemical

4. Post-harvest

Male/female

Hired/family

Mechanical/manual/animal/chemical

b. Intermediation
c. Consumption

Appendix C: IQA Phase 1 key informant interviews: September 2013

Date	Time	Interviewee/Activity	Type of Respon-dent	Region/ City	Setting
30-Aug		Travel DC to Nairobi			
31-Aug		Arrive in Nairobi			
1-Sep		Meet with consultant, travel to Eastern region			
2-Sep	8.30am-11am	District Ag Officer & District Crop Devp't officer	Sector specialist	Eastern	District Ag Office-Machakos Town, Machakos County
	11.20am-12 noon	NCPB Depot Manager	Storage provider	Eastern	NCPB Premises- Machakos Town, Machakos County
	1 pm-2pm	Josphat Kioko-farmer 1	Farmer	Eastern	Farmer's homestead- Machakos County
	2.30 pm-3.30pm	James Mutiso farmer 2	Farmer	Eastern	Farmer's homestead- Machakos County
	4 pm-4.30pm	Janet Nthenge farmer 3	Farmer	Eastern	Katangi Trading Center, Machakos County
	5 pm-5.20 pm	Eunice Mwende Agro Vet 1	Agro-vet	Eastern	Katangi Trading Center, Machakos County
3-Sep	8.30am-10am	Deputy County Director Ag & District Ag Officer	Sector specialist	Eastern	District Agricultural Office-Wote Town, Makueni County
	10.30am-11am	Mrs Ellah Muthane-Trader 1	Trader	Eastern	Wote town-Makueni County
	11.10am-12pm	Mr. Paul Munyau-Trader 2	Trader	Eastern	Wote town-Makueni County
	12.20 pm-1pm	Joshwa Maingi Agro Vet 2-Amazon Agrovet	Agro-vet	Eastern	Wote town-Makueni County
	1.30pm-2pm	Mary Ann Farmer 4	Farmer	Eastern	Farmer's home stead- Makueni County
	2.20pm-3pm	John Muasya Farmer 5	Farmer	Eastern	Farmer's home stead- Makueni County
	4.30pm-5pm	Eng King'oo-artisan 1	Storage provider	Eastern	Artisan's workshop in Machakos town
	5.10pm-5.30pm	Nabea-Chairman of Agrovet union in machakos	Agro-vet	Eastern	District Agricultural Office

Date	Time	Interviewee/Activity	Type of Respon-dent	Region/ City	Setting
4-Sep	11am-1pm	Mr. Sayid-Operations Manager, Pembe Maize Millers	Processor	Nairobi	Industrial area, Nairobi
5-Sep	10am-12 noon	District Ag Officer-Nakuru	Sector specialist	Rift Valley	Nakuru Town, Usin Gishu County
	12.30-4pm	Ag Training Center-Mr Odhiambo	Sector specialist	Rift Valley	Nakuru town
6-Sep	8.30am-9.30	County Director and District Ag Officer	Sector specialist	Rift Valley	County Director Office-Eldoret Town, Uasin Gishu County
	10am-12 noon	Agricultural Show	Sector specialist	Rift Valley	Chepkoilel campus, Uasin Gishu County
	12.20pm-12.45pm	Cathreen-Hardware attendant	Hardware	Rift Valley	Eldoret
	1pm-1.40pm	Lydia-SiSiBo Agro Vet 3	Agrovet	Rift Valley	Eldoret town
	3.30pm-4pm	Amos Maingi- In charge: Mama Millers	Storage provider	Rift Valley	Mama Miller premises near Mois Bridge town
	4.10pm-4.45pm	Henry Ford, Farmer 6	Farmer	Rift Valley	Environs of Mois Bridge
7-Sep	7am-10.30am	Left Eldoret for Nakuru		Rift Valley	
	10.30am-11am	Mr. Ndirangu- Farmer 7	Farmer	Rift Valley	Farmer homestead-Near Nakuru town
	11.30am-12 noon	Mr. Duncan-artisan 2	Storage provider	Rift Valley	Artisan's workshop near Nakuru town
	1pm-2pm	Visited an NGO that bought GrainPro bags for maize storage	Farmer	Rift Valley	
8-Sep		Review and compile results		Nairobi	
9-Sep		Depart Nairobi		Nairobi	

Appendix D: Summary of quantitative baseline survey contents

Section and subject	Unit of measurement	Topics
A. Household identification	Household	County, sub-county, location, sub-location, village, name of household head, name of respondent, household mobile phone numbers
B. Household roster	Up to 20 household members	Sex, age, education, literacy, occupation, income, live/work in other city, religion, ethnicity
C. Poverty Assessment Tool (PAT)	Household	Set of variables determined to be of high correlation with "very poor" status in Kenya (source: USAID); land holdings
D. Access (distance) to facilities	Household	Distance in km to nearest: motorable road, tarmac road, main market (not village market), agricultural extension office, matatu/bus stop
E. Plot & crop roster	Up to 5 plots and 10 crops per plot for long and short seasons in 2013	Start/end month of season, number, size, and primary household member responsible for each plot; crops grown on each plot; area of plot planted with each crop; use of intercropping; earnings from crop sales
F. Storable crop production (storable crops include barley, beans, cowpeas, green grams, maize, millet, njahi, pigeon peas, and sorghum)	Up to 2 storable crops: 1) Maize (if grown) or crop grown on largest amount of land (if maize not grown) 2) Crop grown on 2nd largest amount of land	Quantity planted, quantity that was improved/hybrid seed, how seed acquired, total spent on seed
G. Agricultural inputs	8 inputs	Whether input was used, how much was used, how input was acquired, how much spent on input, used irrigation, how much spent on irrigation
H. Labour	7 agricultural task categories	How many total person-days spent by male household members, how many total person-days spent by female household members, whether hired any labour for task, amount spent on hired labour
I. Storable crop harvest and marketing	Up to 2 storable crops: 1) Maize (if grown) or crop grown on largest amount of land (if maize not grown) 2) Crop grown on 2nd largest amount of land	Quantity harvested; month(s) of harvest; amount kept for consumption; number of discrete sales; month, buyer, quantity, price and motivation for each sale
J. Recall on key maize questions	Household	Maize quantity harvested, sold, and kept for consumption; month and year of (main) sale; month and year of running out of own maize for long (main) rainy seasons in 2012 and 2011
K. Pre-storage handling	19 pre-storage handling practices	Which practice(s) respondent considers to be the best, which practice(s) were used during the 2013, 2012, and 2011 long rainy seasons
L. Storage facilities inventory	10 storage facilities	Which facility(ies) used; number owned; capacity; reasons for preferring facility; amount stored during each 2013 season; length of storage; HH member responsible for storage; storage losses incurred from all causes combined

Section and subject	Unit of measurement	Topics
M. Improved OFS technology	9 improved OFS technologies	Awareness, information sources, adoption, purchase details (price, credit, timing), capacity, use history, reasons for adopting, pesticide use, proper use knowledge
N. Food security and food provisioning	Household	Maize provisioning, maize purchase amounts and expenditures, months of hunger/low food provisioning
O. Assets	Household	Number owned of: cows, sheep, goats, pigs, rabbits, chicken/other poultry, spade/shovel, axe, knapsack sprayer, ox-plough, water pump, tractor, slasher, mattock, chaff cutter, generator, solar panel, donkey/oxcart, pushcart (mkokoteni), bicycle, motorbike, car/taxi/pickup lorry, wheelbarrow, mobile phone, TV

Appendix E: Summary statistics for covariates used in baseline trend regressions

Descriptive Statistics	Eastern	Rift Valley
OFS adoption (binary, =1 if yes)	0.002	0.031
	(0.044)	(0.173)
Maize revenue (in Kenya shillings)	2,025.86	10,501.81
	(9,610.28)	(31,603.87)
Male household head (binary, =1 if male household head)	0.765	0.832
	(0.424)	(0.374)
Age of household head (discrete)	50.569	47.956
	(15.586)	(14.271)
Household head has some secondary or college education (binary, =1 if yes)	0.309	0.301
	(0.462)	(0.459)
Household highest education is some secondary or college (binary, =1 if yes)	0.430	0.436
	(0.495)	(0.496)
Household head can read or write (binary, =1 if yes)	0.825	0.854
	(0.380)	(0.353)
Number of members in household (discrete)	5.100	5.951
	(2.338)	(2.548)
Household member lives outside of village (binary, =1 if yes)	0.189	0.272
	(0.391)	(0.445)
Household is very poor (binary, =1 if yes)	0.310	0.533
	(0.462)	(0.499)
Total area of all owned plots (in hectares)	1.230	1.729
	(1.372)	(2.879)
Labour expenditure in 2013 (in Kenya shillings)	4,057.62	6,825.99
	(11,096.57)	(15,333.04)
Input expenditure in 2013 (in Kenya shillings)	1,172.49	4,123.65
	(2,982.26)	(6,532.94)
Plot irrigated during 2013 (binary, =1 if yes)	0.027	0.018
	(0.161)	(0.134)
Total household person-days spent on farming in 2013 (discrete)	103.920	61.268
	(94.025)	(71.600)
Household needed loans in past year (binary, =1 if yes)	0.212	0.195
	(0.409)	(0.397)
Household labour income in 2013 (in Kenya shillings)	218,585.40	186,527.90
	(768,439.40)	(587,649.40)
Distance to nearest motorable road (in km)	0.434	0.814
	(1.240)	(3.274)
Distance to nearest tarmac road (in km)	10.789	9.796
	(17.172)	(11.849)
Distance to nearest main market (in km)	8.912	10.668

Descriptive Statistics	Eastern	Rift Valley
	(11.879)	(11.755)
Distance to nearest agricultural extension office (in km)	9.666	12.847
	(11.855)	(12.173)
Distance to matatu/bus stop (in km)	3.816	6.920
	(7.493)	(10.607)
Observations (time points)	12,636	1,644
Number of villages	678	90
Standard deviations in parentheses		

Appendix F: Power analysis for the analysis of pilot effects on smallholders

This appendix presents an analysis of the statistical power of the Kenya OFS AgResults pilot impact analysis. As described in the AgResults evaluation design report, the power analysis reflects the regression model specification that will be used to implement the short interrupted time series (SITS) analysis of pilot effects on farmers. That analysis, described in the body of this report, uses pre-intervention data points to form a linear baseline trend, which is then extrapolated into the post-intervention period to serve as the counterfactual for measuring intervention impacts. Deviations from this counterfactual in the post-treatment years will be pooled to obtain an average treatment effect estimate across all post-treatment data points.

Calculation of minimum detectable effect size (MDES). The following formula for MDES—the smallest true impact detectible with high confidence as different from zero—comes from the evaluation design report and is repeated here for completeness:

$$(1)\ MDES = Factor\ (\alpha, \beta, dof) * \sqrt{Var\left(\widehat{\beta_2}\right)}$$

$$= Factor\ (\alpha, Power, dof) * \sqrt{\frac{\sigma_\mu^2\left(1-R_\mu^2\right)}{CJ} + \frac{\sigma_\delta^2\left(1-R_\delta^2\right)}{CJH} + \frac{\sigma_\epsilon^2\left(1-R_\epsilon^2\right)}{CJHTp(1-p)\left(\left(1-R_{time,Post}^2\right)\right)}}$$

where:

α = significance level (set to 0.05 for a 2-sided test).

$Power$ = desired level of statistical power (set to 0.80 which implies an 80% probability of detecting a true effect).

dof = degrees of freedom which equals the total number of observations minus number of covariates and groups (counties, villages, and households).

σ_μ^2 = proportion of the outcome variance that lies across villages within counties.

σ_δ^2 = proportion of the outcome variance that lies across households within villages.

σ_ϵ^2 = proportion of the outcome variance that lies across multiple observations that belong to the same households.

R_μ^2 = proportion of the outcome variance at the village-level explained by covariates included in the model.

R_δ^2 = proportion of the outcome variance at the household-level explained by covariates included in the model.

R_ϵ^2 = proportion of the within-individual outcome variance explained by covariates included in the model.

$R^2_{time,Post}$ = square of the correlation between the *Post* indicator in Equation 1 (which yields the treatment effect estimate) and the time count. Note that this correlation is proportional to the sample size requirements (i.e., a larger correlation increases the number of household keeping the MDES constant).

J = average number of villages per county.

H = average number of households per village.

T = number of observations per household.

p = proportion of observations in the post-treatment period (which equals 0.25).

This MDES formula gives the smallest true impact magnitude that can be detected with the given significance level and statistical certainty. The other parameters that affect the MDES are the number of counties, villages, households, and pre- and post-intervention time points in the data. In order to have a standard measure of power that can be used across all outcomes of interest, MDES is expressed in terms of the standard deviation of the outcome measure (i.e., it corresponds to an "effect size"). This also implies that sum of the all variance components (i.e., outcome variance that lies at the county, village, household, and time levels) is one:

(2) $\sigma_Y^2 = \sigma_c^2 + \sigma_\mu^2 + \sigma_\delta^2 + \sigma_\epsilon^2 = 1$

Expected MDES Estimates. Based on the above formula, we calculated the expected minimum detectable effect sizes (MDESs) for the two outcomes of interest in the smallholder impact analysis– adoption of improved on-farm storage technology and revenue from sale of maize. The calculations are based on the following parameter values and inputs:

- *Values for the village, household, and time-level variance components ($\sigma_\mu^2, \sigma_\delta^2$, and σ_ϵ^2) and the R^2 terms at these levels (R_μ^2, R_δ^2, and R_ϵ^2).* These values are obtained from secondary analysis of the panel data maintained by Tegemeo Institute and Michigan University. From this dataset, we analysed two measures to obtain the corresponding parameter values for our two outcomes: (1) number of 90 kg bags used for storage (for the uptake of on-farm storage solutions) and (2) revenue obtained from maize sold (as a proxy for income).
- *Availability of **four** pre-intervention data points and **two** post-intervention data point for each outcome measure in each region.*
- *Targeted analytic sample for the Eastern region includes 4140 households (5 counties, average of 138 villages per county, and average of 6 households per village) and the targeted sample for Rift Valley includes 540 households (9 counties, average of 10 villages per county, and average of 6 households per village).*
- *Attrition of households between baseline and endline.* Despite our best efforts to reach to and survey all households who completed the baseline survey in the two subsequent survey administrations (intermediate and endline surveys), some attrition will be inevitable. We calculated separate MDES estimates for attrition rates of 10% and 20%. Based on the attrition rate observed in the collection of Tegemeo data over a 10-year period, we do not expect the attrition rate to be larger than 20%.

Table 15. MDES estimates

Region	Outcome Measure	MDES (in standard deviations of the outcome measure)	
		Follow-up Survey Attrition Rate of 10%	Follow-up Survey Attrition Rate of 20%
Eastern	Adoption of On-Farm Storage	0.057	0.061
	Revenue from Maize Sale	0.064	0.068
Rift Valley	Adoption of On-Farm Storage	0.159	0.169
	Revenue from Maize Sale	0.178	0.188

Table 15 shows the corresponding MDES estimates. With 10% attrition, the estimated MDES figures for the first outcome—adoption of on-farm storage—are 0.057 standard deviations for the Eastern region and 0.159 standard deviations in the Rift Valley. These estimates correspond to penetration rates of 0.057 and 0.159 respectively (falling below the pilot's projected respective penetration rates of .06 and .18 [Dalberg, 2012]). With 20% attrition, MDES estimates are slightly larger, 0.061 and 0.169 standard deviations for the Eastern region and the Rift Valley. Table 15 presents similar MDES figures for the second outcome of interest (revenue from maize sale): between 0.064 and 0.068 standard deviations in the Eastern region and between 0.178 and 0.188 standard deviations in the Rift Valley.

Appendix G: Cereal and pulse crop production and sale

Table 16. 2013 long rainy season cereal and pulse crop production and sale (non-maize)

	Eastern			Rift Valley		
	Total	Male HH head	Female HH head	Total	Male HH head	Female HH head
Beans						
Dry beans produced, long rains 2013 (kg)	139.1	144.2	122.8	131.3	136.8	106.6
Green beans produced, long rains 2013 (kg)	24.3	25.4	20.6	13.2	14.2	8.5
Beans kept for household consumption (kg)	101.8	104.4	93.5	69.2	71.6	58.6
Household sold any beans (%)	0.1	0.1	0.1	0.3	0.3	0.3
No. of separate times household sold beans	1.1	1.1	1.1	1.1	1.1	1.0
Total quantity of beans sold in largest sale (kg)	32.1	35.0	23.0	45.3	45.7	43.5
Sale price for largest sale (KES/kg)	49.4	49.7	48.3	62.4	63.2	59.7
Sale price for largest sale (KES/90 kg bag)	4443	4472	4344	5616	5687	5372
Yield (kg/ha)	116	126	88	71	71	.
Cowpeas						
Dry cowpeas produced, long rains 2013 (kg)	92.0	99.9	69.9	38.6	38.6	.
Green cowpeas produced, long rains 2013 (kg)	0.1	0.1	0.1	0.4	0.4	.
Cowpeas kept for household consumption (kg)	1.1	1.1	1.0	1.0	1.0	.
Household sold any cowpeas (%)	21.5	22.9	17.5	76.0	76.0	.
No. of separate times household sold cowpeas	50.1	52.0	45.3	80.0	80.0	.
Total quantity of cowpeas sold in largest sale (kg)	4,505	4,676	4,074	7,200	7,200	.
Sale price for largest sale (KES/kg)	259	285	187	389	3889	.
Sale price for largest sale (KES/90 kg bag)	0.1	0.1	0.1	-	-	-
Yield (kg/ha)	129.9	129.5	131.3	.	.	.
Millet						
Dry millet produced, long rains 2013 (kg)	148.8	157.4	111.3	173.5	139.0	450.0
Green millet produced, long rains 2013 (kg)	23.3	28.6	0.0	9.0	11.3	0.0
Millet kept for household consumption (kg)	121.1	135.5	58.8	163.5	127.7	450.0
Household sold any millet (%)	0.1	0.1	0.2	0.1	0.1	0.0
No. of separate times household sold millet	1.1	1.0	1.5	1.0	1.0	.

	Eastern			Rift Valley		
	Total	Male HH head	Female HH head	Total	Male HH head	Female HH head
Total quantity of millet sold in largest sale (kg)	21.8	19.1	33.7	15.0	18.8	0.0
Sale price for largest sale (KES/kg)	44	43	47	12	12	.
Sale price for largest sale (KES/90 kg bag)	3942	3851	4259	1080	1080	.
Yield (kg/ha)	523	545	418	854	817	1112
Pigeon peas						
Dry pigeon peas produced, long rains 2013 (kg)	86.7	75.2	114.4	.	.	.
Green pigeon peas produced, long rains 2013 (kg)	53.6	50.1	62.5	.	.	.
Pigeon peas kept for household consumption (kg)	74.8	60.3	111.0	.	.	.
Household sold any pigeon peas (%)	0.1	0.1	0.2	.	.	.
No. of separate times household sold pigeon peas	1.0	1.0	1.0	.	.	.
Total quantity of pigeon peas sold in largest sale (kg)	17.6	16.9	19.4	.	.	.
Sale price for largest sale (KES/kg)	47	45	52	.	.	.
Sale price for largest sale (KES/90 kg bag)	4226	4007	466	.	.	.
Yield (kg/ha)	211.3	153.7	349.4	.	.	.

Table 17. 2013 short rainy season cereal and pulse crop production and sale (Eastern only)

	Total	Male HH head	Female HH head
Beans			
Dry beans produced, short rains 2013 (kg)	102.4	379.8	107.3
Green beans produced, short rains 2013 (kg)	24.5	160.7	18.7
Beans kept for household consumption (kg)	89.5	343.4	94.2
Household sold any beans (%)	5.5%	22.8%	5.6%
No. of separate times household sold beans	1.0	0.2	1.0
Total quantity of beans sold in largest sale (kg)	13.3	163.8	13.8
Sale price for largest sale (KES/kg)	52	23	51
Sale price for largest sale (KES/90 kg bag)	4659	2056	4568
Yield (kg/ha)	5,793.1	235,840.2	7,449.3
Cowpeas			
Dry cowpeas produced, short rains 2013 (kg)	69.7	161.3	68.1
Green cowpeas produced, short rains 2013 (kg)	28.0	44.5	28.1
Cowpeas kept for household consumption (kg)	65.3	155.6	63.1
Household sold any cowpeas (%)	7.5%	26.4%	8.0%
No. of separate times household sold cowpeas	1.0	0.0	1.0
Total quantity of cowpeas sold in largest sale (kg)	9.9	47.8	10.8
Sale price for largest sale (KES/kg)	41	20	41
Sale price for largest sale (KES/90 kg bag)	3707	1792	3684
Yield (kg/ha)	198.5	456.4	191.6
Green grams			
Dry green grams produced, short rains 2013 (kg)	104.9	730.4	120.1
Green green grams produced, short rains 2013 (kg)	6.7	20.5	6.9
Green grams kept for household consumption (kg)	31.5	53.9	33.6
Household sold any green grams (%)	32.2%	46.8%	32.1%
No. of separate times household sold green grams	1.0	0.2	1.0
Total quantity of green grams sold in largest sale (kg)	68.3	714.6	80.2
Sale price for largest sale (KES/kg)	67	18	67
Sale price for largest sale (KES/90 kg bag)	5988	1645	5992
Yield (kg/ha)	176.0	932.9	192.5
Maize			
Dry maize produced, short rains 2013 (kg)	171.6	486.3	176.9
Green maize produced, short rains 2013 (kg)	36.7	222.1	33.1

	Total	Male HH head	Female HH head
Maize kept for household consumption (kg)	137.0	353.1	141.6
Household sold any maize (%)	6.7%	25.0%	6.8%
No. of separate times household sold maize	1.1	0.4	1.1
Total quantity of maize sold in largest sale (kg)	28.9	179.2	28.6
Sale price for largest sale (KES/kg)	31	10	32
Sale price for largest sale (KES/90 kg bag)	2831	872	2837
Yield (kg/ha)	1,304.1	32,316.8	1,280.1
Millet			
Dry millet produced, short rains 2013 (kg)	77.8	100.1	84.0
Green millet produced, short rains 2013 (kg)	6.0	20.6	5.3
Millet kept for household consumption (kg)	61.2	74.9	63.7
Household sold any millet (%)	8.3%	27.9%	9.8%
No. of separate times household sold millet	1.0	0.0	1.0
Total quantity of millet sold in largest sale (kg)	16.3	62.3	19.2
Sale price for largest sale (KES/kg)	60	30	60
Sale price for largest sale (KES/90 kg bag)	5440	2710	5440
Yield (kg/ha)	272.6	635.6	290.0
Pigeon peas			
Dry pigeon peas produced, short rains 2013 (kg)	70.1	215.6	74.5
Green pigeon peas produced, short rains 2013 (kg)	25.5	56.0	26.4
Pigeon peas kept for household consumption (kg)	71.9	215.5	77.9
Household sold any pigeon peas (%)	7.1%	25.7%	7.6%
No. of separate times household sold pigeon peas	1.0	0.0	1.0
Total quantity of pigeon peas sold in largest sale (kg)	5.8	26.3	6.0
Sale price for largest sale (KES/kg)	48	27	42
Sale price for largest sale (KES/90 kg bag)	4345	2408	3803
Yield (kg/ha)	240.7	582.3	168.0

Appendix H: Detailed regression results for OFS adoption and maize revenue

Table 18 shows the detailed baseline trend regression results for the OFS adoption outcome as discussed in Section 4.2. Appendix E contains summary statistics on all covariates included in the baseline trend regressions.

Table 18. Detailed regression results: OFS adoption

Outcome: Household Has Adopted Any Improved OFS Technology		
	Eastern	Rift Valley
Time (1, 2, or 3)	0.001***	0.010***
	(0.000)	(0.002)
Male household head (binary, =1 if male household head)	0.001	0.003
	(0.002)	(0.016)
Age of household head (discrete)	-0.000	0.001
	(0.000)	(0.000)
Household head has some secondary or college education (binary, =1 if yes)	-0.001	-0.007
	(0.002)	(0.016)
Household highest education is some secondary or college (binary, =1 if yes)	0.001	0.000
	(0.001)	(0.014)
Household head can read or write (binary, =1 if yes)	0.002	0.010
	(0.002)	(0.020)
Number of members in household (discrete)	-0.000	0.002
	(0.000)	(0.003)
Household member lives outside of village (binary, =1 if yes)	0.004**	-0.024
	(0.002)	(0.016)
Household is very poor (binary, =1 if yes)	0.001	-0.003
	(0.002)	(0.015)
Total area of all owned plots (in hectares)	-0.000	-0.001
	(0.001)	(0.002)
Labor expenditure in 2013 (in Kenya shillings)	0.000	-0.000
	(0.000)	(0.000)
Input expenditure in 2013 (in Kenya shillings)	-0.000	0.000
	(0.000)	(0.000)
Plot irrigated during 2013 (binary, =1 if yes)	-0.003	-0.015
	(0.004)	(0.058)
Total household person-days spent on farming in 2013 (discrete)	-0.000	-0.000
	(0.000)	(0.000)
Household needed loans in past year (binary, =1 if yes)	-0.002	0.021
	(0.002)	(0.015)
Household labor income in 2013 (in Kenya shillings)	0.000	-0.000
	(0.000)	(0.000)
	0.000	0.003

Distance to nearest motorable road (in km)	(0.001)	(0.002)
Distance to nearest tarmac road (in km)	-0.000*	0.001
	(0.000)	(0.001)
Distance to nearest main market (in km)	0.000	-0.002*
	(0.000)	(0.001)
Distance to nearest agricultural extension office (in km)	-0.000	0.001
	(0.000)	(0.001)
Distance to matatu/bus stop (in km)	-0.000	0.001
	(0.000)	(0.001)
Constant	-0.002	-0.062
	(0.004)	(0.050)
Observations (time points)	11,952	1,542
Number of villages	677	90
Standard errors in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		

Table 19 shows the detailed baseline trend regression results on maize revenue as discussed in Section 4.3. Appendix E contains summary statistics on all covariates included in the baseline trend regressions.

Table 19. Detailed regression results: maize revenue

Outcome: Long Rainy Season Maize Revenue (KSH, inflation-adjusted)		
	Eastern	**Rift Valley**
Time (1, 2, or 3)	485.412***	1,907.014***
	(89.193)	(607.717)
Male household head (binary, =1 if male household head)	-210.379	2,368.002
	(267.033)	(2,746.048)
Age of household head (discrete)	-6.859	76.918
	(8.043)	(78.263)
Household head has some secondary or college education (binary, =1 if yes)	758.936***	-4,078.370
	(278.644)	(2,556.741)
Household highest education is some secondary or college (binary, =1 if yes)	-176.601	3,675.256
	(252.094)	(2,327.362)
Household head can read or write (binary, =1 if yes)	137.797	2,432.601
	(336.956)	(3,361.998)
Number of members in household (discrete)	-110.768*	-618.653
	(58.057)	(490.466)
Household member lives outside of village (binary, =1 if yes)	505.479*	5,614.310**
	(292.095)	(2,268.061)
Household is very poor (binary, =1 if yes)	-404.882	-4,457.906*
	(286.974)	(2,485.353)

Total area of all owned plots (in hectares)	612.908***	59.345
	(85.072)	(368.497)
Labor expenditure in 2013 (in Kenya shillings)	0.213***	0.245**
	(0.010)	(0.100)
Input expenditure in 2013 (in Kenya shillings)	0.384***	2.094***
	(0.038)	(0.242)
Plot irrigated during 2013 (binary, =1 if yes)	-1,450.618**	4,710.045
	(733.353)	(7,534.385)
Total household person-days spent on farming in 2013 (discrete)	1.962	-8.875
	(1.298)	(15.806)
Household needed loans in past year (binary, =1 if yes)	226.075	-1,588.421
	(273.570)	(2,546.335)
Household labor income in 2013 (in Kenya shillings)	0.000**	-0.001
	(0.000)	(0.002)
Distance to nearest motorable road (in km)	-75.426	-186.350
	(90.879)	(300.276)
Distance to nearest tarmac road (in km)	4.982	143.976
	(9.489)	(153.810)
Distance to nearest main market (in km)	-10.404	186.673
	(15.583)	(147.154)
Distance to nearest agricultural extension office (in km)	-14.360	-4.694
	(15.504)	(136.924)
Distance to matatu/bus stop (in km)	1.011	-320.146**
	(19.603)	(162.613)
Constant	736.428	-9,458.994
	(681.424)	(6,748.364)
Observations (time points)	11,567	1,447
Number of villages	677	90
Standard errors in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		